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New Light

➤ IT IS CURIOUS, in looking back over the literature of great developments in science, how a principle that is clear now, in the light of our later knowledge, was obscured then. The difficulty so often lies not in lack of data but in inability to explain what had been learned in terms that would fit the accepted beliefs of the time.

Tracer chemistry, which uses the radioactive forms of elements to signal their progress through chemical reactions, is one of those giant steps by which the science passes a barrier and comes out into new territory. In this issue of CHEMISTRY the newest and the earliest applications of tracer chemistry are reprinted.

The newest is from the semi-annual report of the Atomic Energy Commission, just issued. It tells how suitable radioactive isotopes can be selected to give an on-the-spot broadcast—a play by play report—of life processes and other reactions hitherto hidden and secret.

The earliest account is the "Classic." Only thirty-five years ago the trick was first tried, by men still active in sub-atomic affairs. Yet it is possible to see in Dr. Hevesy's account the daring with which he jumped the mental hurdle that kept others back. It is shown by the word "non-separable."

Transmutation has given chemists a lot of worry through the ages, first to prove that it can't happen, then to prove that it can. In 1913 they knew it couldn't. Therefore every new protean shape of the radioactive products was labelled a new element. The properties of each were studied intensively. exactly like which elements. But the bold step was to substitute the radio-element for the stable one, or to mix the two, and declare that the data revealed by radioactive effects showed what the stable element was undergoing beyond our ordinary powers of observation. Radioactivity threw a new light on chemical reactions. But it was a long time before chemists could bring themselves to admit that radium E is also bismuth, that radium D is also lead.

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➤ SAVING YOUR HOUSE *from burning down is the object of constant research. Chemists study the properties of many substances to find those best suited to the purpose, and treat the old stand-by, water, to make it more effective.*

Wet Water Fights Fire

by A. C. MONAHAN

➤ WATER ALONE, foe of fire, is losing its rank as the number one fire fighter. Wetter water, fog-foams and fire-extinguishing chemicals are taking its place. Chemistry is playing an important part in fire fighting and in fire prevention.

It has long been realized that fire fighters need a more effective and less destructive weapon than water. Water frequently does more damage than the fire it puts out. This accounts for the popularity of carbon dioxide gas, used for years to fight fire. This heavier-than-air non-combustible gas smothers fire by keeping oxygen away. But in major fires its usefulness is limited.

Important among the newer weapons against fire is what is called wetter water. This is ordinary water to which chemicals have been added which give it power to penetrate well into burning materials to the regions where combustible gases form. The chemicals lower the surface tension of water, which is remarkably high. Drops of water alone are almost as stand-off-ish as those of mercury.

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Fog-foams are particularly effective against gasoline and oil fires, which have become more common with the present wide use of these fuels. Some of the newer gases are more suitable for fire-fighting under certain conditions than the carbon dioxide standby.

These chemical fire-fighters are not new in the sense that their use has just been discovered, but during the past few years improved chemicals and methods of application have been developed.

New weapons for fire-fighting are of great importance at the present time. Annual losses by fire are much greater than in the prewar years. These increased losses are not due merely to inflated property values. The actual number of fires has increased, and this applies to conflagrations as well as small fires. Needless destruction of property and resources by fire in the United States runs considerably over $2,000,000 a day.

Surface Active Agents

The strategy is to use chemicals which let water soak further into materials. Such chemicals have been much improved in recent years. They are used in washing clothes as well as in fire-quenching. This so-called wetter water gets rapidly into burning materials, through wood char, wall-board, upholstery, baled cotton and paper, to the zone where heat is causing the formation of combustible gases to add to the fire.

But not all chemicals which reduce surface tension are satisfactory for fire fighting. Although sulfonated compounds are the secret of most surface active agents, there is a large variety of these materials on the market, and the application of them is rapidly becoming divided into detergents, the more soapy type, and wetting agents, whose objective is to make water more penetrative.

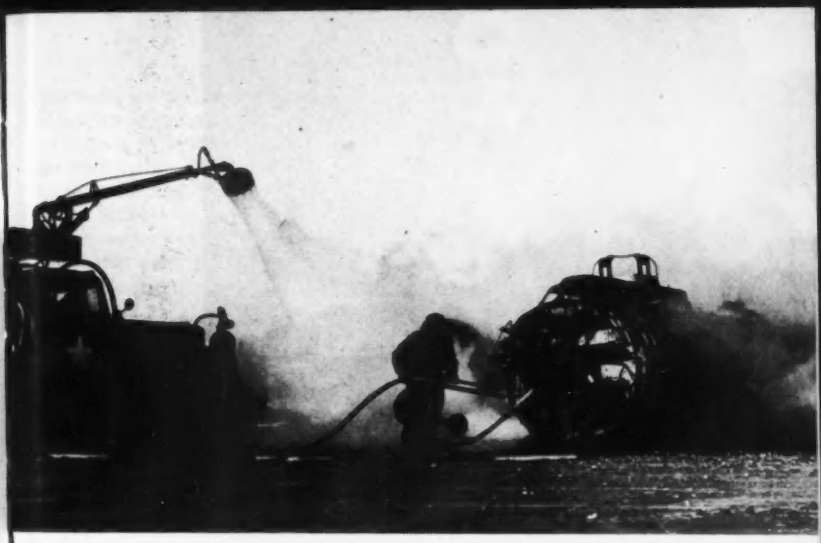
Two companies are at present concentrating on making wetting agents for fire fighting purposes, while several of the companies specializing in fire fighting equipment are marketing similar products under their own brand names.

Liquid surface active agents which can be pumped through booster tanks and mixed with the stream of water thrown out by a fire engine are manufactured by Arnold Hoffman and Co. of Providence, R.I., who claim that their "Drench" pioneered in this field, and by Carbide and Chemicals Corporation of New York, who claim that their "Unox" has the latest improvements. Both materials have had extensive trials, both in test situations and against forest fires out of control. Both add to their wetting power the important quality of mixing with any kind of water available and of being non-corrosive to iron tanks and to brass pipes and nozzles.

Older Type Chemicals

In extensive tests on the fire-extinguishing effectiveness of chemicals, conducted by the U. S. Forest Products Laboratory, Madison, Wis., just before the war, a long list of chemicals was tested, all of which had some value.

Potassium acetate, potassium bicarbonate and potassium carbonate were found to have pronounced flame-extinguishing capacity. Phosphoric acid, diammonium phosphates, monoammonium phosphates and boric acid have pronounced glow-extinguishing



➤ FOG-FOAM *equipment is tested by the army for use against airplane fires. Fire fighting equipment to be carried aboard a plane presents special problems not yet satisfactorily solved.*

and total-extinguishing capacity. Other chemicals that showed lower but definite total-extinction effectiveness in concentrated solutions include ammonium sulfate, lithium chloride, magnesium chloride and zinc chloride.

Navy Bean Soup, Fog-Foam

With the tremendous increase in the use of gasoline, fuel oils and other petroleum products in engines, heating, cleaning and other applications, a special fire-fighting problem is presented. Water is not effective in killing an oil or gasoline fire. Fog-foam seems to be the answer.

The so-called "Navy bean soup," used on shipboard and elsewhere by the U. S. Navy where gasoline and oils are used in large quantities, is made from soybeans, fishscales and iron salts. When applied with water through jets to produce a fine mist-like spray, it can be spread on in layers several inches thick which seal in combustible gases and seal out oxygen. Surface active agents are obviously not used with chemicals designed to build up foam.

The snowy bubbles of fog-foam last for hours. Its adhesive quality makes it stick to anything. Even a high wind will not blow it away. Fog-foam fire-fighting systems are now installed on Navy aircraft carriers. They are also carried by fire-fighting tugs for killing fires on other vessels or in harbor neighborhoods.

One important use for the foam method is in fighting fires in above-the-ground giant storage tanks where petroleum or its products are stored

➤ HOSE-NOZZLE *design is always subject to improvement. This plastic nozzle is one of the fields in which molded material is being tried as a possible replacement for machined metal.*

for distribution or held for processing. In this case the fog-foam may be pumped into the bottom of the burning tank through the oil pumping line itself. When applied in this way it rises through the oil, cooling it below ignition temperature, thus killing the fire.

Carbon dioxide has long been, and still is, the principal fire-extinguishing gas used in household and factory extinguishers. Carbon tetrachloride, a heavy liquid easily vaporized, is also used in equipment of this type. More installations of these effective extinguishers would go far toward lessening present fire losses.

Methyl bromide has been advocated as a fire-extinguishing agent, particularly for aircraft engine fires. It is

said to be the most efficient material commercially available for the purpose, from 20% to 100% more effective than carbon dioxide. But this gas is poisonous and highly corrosive. It cannot be used in contact with certain metals, among which is aluminum. It is being used to a certain extent, but not for fires in passenger or crew compartments.

Freons Kill Fire

Among fire-extinguishing vapors are the fluoro-chloro-methane compounds known as freons, widely used in refrigerators and air-conditioning equipment. They are harmless to man, being non-toxic, non-combustible, non-explosive and non-irritant.

The U.S. Bureau of Mines recommends one of the freons, freon 11, for use in extinguishing gasoline fires around mines, a rather common occurrence. In tests with six gases on three different types of gasoline, it found Freon 11 most effective. The other gases tested were freon 12, freon 21, carbon dioxide, automobile exhaust gas and nitrogen. They were effective in fire-extinguishing in the order named. The numbers in the names of the freons refer to the number of fluorine atoms in the molecule. Freon 11 has the formula CCl_3F. Freon 12 is CCl_2F_2; 21, $CHCl_2F$.

Fire Prevention Best

Almost every fire has a small beginning. Careless persons are often responsible. Discarded glowing matches and butts of cigarettes start more fires than any other single cause, it is claimed. One way to prevent such fires would be through wider use of non-combustible materials. Chemical treatment to make materials like wood and textiles fire resistant would also help. Chemists have worked for years to develop such fire-retardant compounds, and have met with considerable success.

Wood is treated both by impregnation and by coatings. A paint containing ammonium phosphate gives wood an excellent fire-resisting finish. Cementiferous paints developed in England are claimed to have high fireproofing value. Cloth is made fire-resistant by a variety of substances, classified as retardants.

It is important to remember that there are many successful methods of treating clothes and other fabrics, such as draperies and upholstery materials, to lessen danger from fire. Their wider use would prevent many destructive fires and save many lives.

On the Back Cover

➤ OUR WORST ENEMY *rages unchecked here, because this fire was set in a building scheduled for removal anyway. The occasion was used to learn more about fire, so that better fire fighting methods could be planned. Wetter water, which penetrates further and more quickly into combustible material, is one of the improved new ways of preventing destruction.*

Corrosion Problem in Many Industries Attacked in Various Ways by Research

Longer Life For Materials

A round-up of methods to combat corrosion reveals that scientists are developing protective measures ranging from substitution of less reactive materials to prevention of reactions that cause damage.

➤ THE CORROSION of steel underground, such as in pipes, was adequately prevented over test periods ranging from three to six years by connecting zinc cylinders to the steel, the National Bureau of Standards has found in tests conducted by I. A. Denison and Melvin Romanoff of its staff.

Underground pipe lines have been widely and effectively protected from the corrosive action of the soil by the use of electricity for some time. If an electrical supply is handy, protection can be easily applied. But pipelines transmitting oil, gasoline and natural gas over vast distances are often too far away from electrical power to permit its economical use. It is for protection in these remote areas that the Bureau has sought improved methods.

Corrosion of steel in the soil is caused largely by electric currents set up by chemical action. Technically, it is often caused by differences in electrical potential of local areas on the corroding surface. Those areas whose potentials with respect to conventional reference electrodes are relatively high are designated as anodes, while areas of lower potential are known as cathodes. The electric current associated with corrosion flows toward, rather than from, the cathode areas. The cathode areas are not, therefore, subject to corrosion, but the anode areas are.

However, if sufficient current from an external source is caused to flow toward the corroding surface, the potential difference between the local anodic and cathodic areas is eliminated, and consequently the cause of corrosion.

A source of electrical energy for corrosion protection, in areas where underground pipe is removed from other electric power, can be provided by the galvanic corrosion of bars of the electronegative metals, zinc, magnesium or aluminum, buried at suitable intervals along the right of way and connected to the pipe line.

The Bureau's recent investigations were relative to the behavior of zinc anodes for cathodic protection in various types of soil. Experimental zinc-steel couples were installed at eight sites. The cathode of the couple was a small steel ring, to which was connected either one, two or three zinc anodes. Unconnected steel rings and zinc cylinders were also buried at each test site. Data obtained, among other information, indicate the proper amount of current to give just the protection necessary.

Low-Alloy Steels

➤ IT IS UNSAFE to draw general conclusions in the atmospheric corrosion testing of low-alloy steels from tests of limited character, the American

Society for Testing Materials was told by H. R. Copson of the International Nickel Co., Bayonne, N.J. He contrasted results on similar samples exposed at Bayonne and at Block Island, R.I., with 71 samples over a period of five years.

Corrosion results depend upon the location of the tests, whether industrial, marine or rural; on the duration of the tests; whether the samples are sheltered or boldly exposed, and on the weather particularly as regards wetness and pollution. The method of estimating corrosion, whether weight loss, pit depth, or time to disintegrate, is also a factor. In thin steel pit losses are more important than weight losses.

The result of the conditions encountered at the two locations by samples with various alloying metals such as copper, manganese, chromium and nickel, was presented to the meeting. The effect of atmospheric pollution was emphasized as important. The corroding elements are sulfur dioxide, and such solids as chlorides, sulfates and other active materials.

Secret "Alloy X"

➤"Alloy X," a war-born metal for lining gun bores to prolong their firing life, has properties "so remarkable as to justify concealing even the basic metal from which it was evolved," it is disclosed in a new book, Rockets, Guns and Targets, edited by John Burchard of the Massachusetts Institute of Technology, published by Little, Brown and Company. The book as a whole is an account of the strides made in many fields of ordnance research by workers of the Office of Scientific Research and Development during the war.

Although the account does not state what Alloy X is, it seems safe to infer that it is not a new kind of steel, for it was one of the materials tested for barrel liners when it was found that no improvement in steel itself could prevent rapid corrosion and hence loss of accuracy and velocity under the high powder-pressures used in modern military firearms and the even higher ones anticipated for the future. Steel gun linings are weakened and destroyed in three ways during firing: through the melting of a surface film by the intense heat of the burning powder, through its chemical action under the heat and high pressure, and through the friction of the projectile as it passes through the bore. Corrosion results are serious: the exceedingly costly 16-inch naval gun becomes useless after about 200 rounds and has to be relined; near the other end of the size scale, the .50-caliber machine-gun barrel sometimes loses so much in accuracy after a few minutes of aerial combat that the plane is as good as unarmed.

Two methods of protecting gun-barrel steel are disclosed in the new book. One was the insertion of corrosion-resistant liners, either for the full length of the barrel or at least near the powder-chamber, where corrosion is worst. Stellite, a cobalt-chromium-tungsten alloy, proved especially valuable for this purpose. The other method was a chromium plating on the whole surface of the bore. This plating was sometimes made a little thicker towards the muzzle. This imparted a slight choke, thereby giving the bullet some extra foot-seconds of muzzle velocity.

Other topics discussed at length in

the book are the development of the many types of rockets used in the war, the recoilless 4.2-inch chemical mortar that was really a low-angle cannon, and the frangible bullet that made combat target practice more realistic yet perfectly safe.

Resistance to innovations by civilian "interlopers," and toe-dragging tactics by some of the "heavy brass" of the old-line Services comes in for some salty discussion in a chapter headed "Sand in the Gears."

Oxygen Destroys Plastics

➤ PLASTICS, rubber, textiles and finishes have their most potent threat, unless protected, in oxygen, the element essential to human life and well being, the American Chemical Society was told by Dr. Burnard S. Biggs of the Bell Telephone Laboratories, Murray Hill, N.J.

Oxidation, a sort of chain reaction initiated by heat, light, and liberation of a potent form of oxygen, causes these materials to become brittle, weakens their resistance to strain, decreases toughness and, in some cases, lessens their electrical insulation properties.

The three general methods of stabilization against oxygen, he said, are the removal of this element, as in the packaging of foods in nitrogen and the filling of light bulbs with nitrogen instead of air; the removal of the source of energy, as in the use of chemicals known as screens which absorb light; and the application of antioxidants which are thought to act as chain stoppers.

Other components of the atmosphere, such as water vapor and ozone, also cause deterioration of plastic and rubber, but their threat is not so great as oxygen. Water vapor is harmful chiefly with materials which can be chemically decomposed by water, and then only when acids or alkalis are present.

Ozone, a pungent form of oxygen, causes rubber to crack. However, it has no reaction if the rubber is covered with a protective film of wax.

Unbalanced Equations

Don't Bother to Whip Up Anything For Me

➤ "CAN YOU tell me how to remove a long streak of brownish stain from a marble top where a mahogany framed mirror rested for many years?"—*A syndicated Household Hints column.*

Ans: "Since we cannot be sure just what the stain is, you may have to try several agents in the poultice before one is successful. Start by mixing turpentine with hydrated lime, cornmeal or something similar."

Pain Killers, New Mental Treatments, Sulfa for Cholera, Hypertension Aid

Chemistry Aids Medical Advances

One of chemistry's great uses today is in the laboratories and clinics where the medical treatments of the future are being developed. From many places, CHEMISTRY *brings details of these important advances.*

Better For Cancer Pain

▶ A DRUG better than morphine for stopping the intense pain of dying cancer patients is now available. Called metopon, it is derived from opium, like morphine. It is habit-forming, like all opium drugs, but addiction to it builds up more slowly.

This latest step in man's conquest of pain was reported by Dr. Nathan B. Eddy, of the U.S. National Institute of Health, Bethesda, Md., speaking before the analgesics conference of the New York Academy of Sciences.

Metopon has no equal for oral (mouth) administration for chronic pain, Dr. Eddy reported, if its use is started before tolerance and dependence on other narcotics have developed.

The patient being treated with metopon does not get as much feeling of well-being (euphoria) as injections of morphine would give him. Tolerance to the drug, making larger and larger doses necessary, develops more slowly than with morphine.

Metopon is made from opium by a "distressingly complicated process."

Dr. Lyndon F. Small, National Institute of Health chemist, told the conference that for over a decade chemists have attempted to produce a drug as effective as morphine in stopping pain without morphine's ability to make addicts of its users. Metopon does not quite succeed in this respect. No active morphine derivative has yet been made which is free of addiction liability.

Given by mouth metopon has given fair or better relief of pain in the last stages of cancer in 74 out of every 100 patients, Dr. Eddy reported. In those patients who had not previously been given morphine or related substances, metopon gave fair or better pain relief in 91 out of every 100 patients.

Metopon, being an opiate, comes under the control of the Federal narcotic drug laws. In order to make doubly sure that it will not be misused and create new drug addicts, it has been released only for use to relieve chronic pain in cancer patients. This was possible because the patent for the drug was assigned to and is now owned by the United States government. The distribution procedure provided that doctors prescribing it should supply Dr. Eddy with information on results of its use.

A plan is now being considered for extending metopon's distribution to other chronic pain sufferers.

H. J. Anslinger, U.S. Commissioner of Narcotics, told the conference that if the new plan goes into effect, metopon will be available in drug stores on

a physician's prescription. Its production and distribution, however, will still be subject to the Federal narcotic drug laws.

Methadon "Best Pain-Killer"

➤ BEST DRUG so far for the relief of pain in dying cancer patients is the synthetic drug, methadon, known also as amidone and dolophin. Its superiority among a group of four new pain-killing drugs tested at Memorial Hospital, New York, was reported by Dr. J. S. LaDue at the New York Academy of Sciences conference on new analgesics.

The other three drugs tested were two known only as NU 896 and NU 1196 and metopon. (See article above.)

Methadon is superior in some respects to the opiates, which include morphine itself, Dr. LaDue reported. One of its advantages is that it does not produce euphoria, or a feeling of well-being, except in very large doses. Small doses of opiates uniformly produce euphoria. For nervous, apprehensive patients, however, the lack of euphoria is a disadvantage and for these methadon would not be as desirable as opiates.

Methadon, which is definitely a narcotic drug, is just about ready for release.

A dozen or more new pain-killing drugs are still waiting to be tested. The Memorial group expects to try these as soon as possible in the hope of finding the ideal pain-killer for cancer patients.

Demerol To Relieve Pain

➤ DEMEROL, synthetic drug developed in Germany and not related to morphine or opium, is a "noteworthy contribution to the patient afflicted with pain of one form or another," Dr. Fredrick F. Yonkman, lecturer in pharmacology at Columbia University College of Physicians and Surgeons, stated at the New York Academy of Sciences analgesics conference.

This drug was made in efforts to improve on atropine, or belladonna. It relaxes spasm of smooth muscles such as the lower intestines and uterus, thus relieving pain. But part of its pain-relieving action is due to its effect on the central nervous system. In this effect it comes between codeine and morphine.

It has been widely used for relief of pain in childbirth and is also used for relief of gall bladder spasm and in some kinds of asthma.

Unfortunately, demerol can cause addiction. Over 200 cases of addiction to it in patients who had not been addicted to other narcotic drugs have been studied at the U.S. Public Health Service Hospital at Lexington, Ky. Demerol is now subject to Federal narcotic laws.

Sulfa Drug Against Cholera

➤ A NEW SULFA drug may be the weapon of the future against cholera, dysentery and some other intestinal infections.

The drug is called phthalylsulfacetimide. It was developed by Dr. Harry Seneca, research associate at Columbia University College of Physicians and Surgeons, and Dr. Edward Henderson, director of clinical research of Schering Corporation. They were seeking a drug for dysentery and other similar infections that would be safe enough and cheap enough to be sold over the drug store counter like aspirin.

When the cholera epidemic broke out in Egypt last fall, tests of the new sulfa drug had progressed far enough so that the scientists thought it would have value in this disease. Dr. Seneca flew to Egypt in October with a supply of the drug.

Some 500 patients were treated. Because of the chaotic conditions and lack of trained personnel, adequate records could be gotten on only 43. But of these 43, only one died. That gives the new drug a record of saving lives at the rate of about 97 out of 100 in an epidemic in which almost 50 out of every 100 died. The drug's success in cholera depends on its being given within the first three days of sickness.

The drug has been given to patients in the New York area suffering from ulcerative colitis and from acute intestinal inflammation. In the latter condition, some patients were relieved of symptoms in one day and all nine were cured on the fifth day. Of the 28 ulcerative colitis patients, 18 improved when given the drug. The drug is not expected to cure this condition, but to clean up secondary infection and give the ulcers a chance to heal.

Success of the drug and its safety are believed due to its unique ability to penetrate the walls of the intestines without being absorbed into the blood stream. It is given by mouth either in pills or in a powder dissolved in milk or water. It is not yet on the market.

CO_2 For Mental Cases

➤ CARBON DIOXIDE, the soda-water gas, is helping the mentally sick back to health the American Psychiatric Association was told at its meeting held in Washington.

The patients inhale the gas, mixed with oxygen. After 15 or 20 inhalations, they fall quietly into a deep slumber. Sometimes they dream. Sometimes not. When they wake up they are more relaxed and comfortable. And best of all, they can face their problems, talk them over with the psychiatrist, and win their way back to mental health.

Success with this treatment in 18 out of 37 patients was reported to the American Psychiatric Association by Dr. J. A. Kindwall and five associates of the Milwaukee Sanatorium, Wauwatosa, Wis. There was no noticeable change in 11 and eight had their symptoms aggravated.

One patient who had been in a psychoneurotic depression for three years, with physical as well as mental symptoms, had 75 treatments and in five months was well. Another patient, with schizophrenic depression, became more tense under the treatments. They distressed her so that she was given only 15. She got well after electro-shock treatments given during insulin coma. But looking back, she herself attributed much of her improvement and recovery to the carbon dioxide treatments. Whether she was right or wrong about this, her physicians do not know.

The patients who had pleasant or neutral feelings with the treatment were helped, while those who were distressed or frightened by the carbon dioxide experience were not.

Signs of addiction to the treatment appeared, even in patients who were distressed by it. Because they felt relaxed and more comfortable after each treatment, they often asked for more.

Several of the doctors took the treatments themselves. One took 97, averaging four a week with 30 to 40 inhalations of the gas each time. In about half the sessions he could recall no dreams but was aware that thoughts, mostly of daily events, were going through his mind. For the rest of the treatments he could recall dreams of a pleasant nature, often with romantic coloring. During one treatment he dreamed of an atomic bomb explosion but with no fear or unpleasantness.

"It was like a total dissolution, a pattern completed," he reported. He felt relaxed and comfortable during the dream. This dream occurred not long after one of his patients had a terrifying atom bomb dream while under the gas.

This doctor's personality did not change under the treatments, so far as he and his associates could tell.

Associated with Dr. Kindwall in the study of this new treatment were: Drs. Lewis Danziger, Ray Headlee, Carroll W. Osgood, H. Gladys Spear and Benjamin A. Ruskin.

Histamine For Delusions

➤ DELUSIONS can be banished and some mental patients can be helped to recovery by histamine, a chemical believed to play a part in hayfever suffering. Dr. E. O. Niver of Eau Claire, Wis., described to the American Psychiatric Association the dramatic recovery of a 26-year-old man.

The patient had been depressed for some time. His father had committed suicide and the young man was convinced that he suffered from a hopeless condition. He had the delusion that part of his digestive tract was "dead and his food was wasted." This delusion showed immediate improvement when histamine treatment was started and within one week it had cleared up entirely. The patient's judgment, however, was still defective, so that he refused further voluntary treatment.

A stocky, mildly paranoid woman who was beset by suspicions that her husband was unfaithful was also helped by histamine treatment. Her suspicions made her agitated and her inner sense of hostility at times reached a dangerous pitch. After five injections of histamine with psychotherapy she became calmer, gained insight into her problems, and for several months has gotten along very well.

A 45-year-old woman with some tendency to depression came to the hospital because of excruciating, knife-like headaches. These were not due to nervous and muscular tension, nor to migraine. Sedatives failed to relieve them. She began to improve under histamine treatment. Then, one day, the drug caused her headache to become much worse. At that point she became very hostile and said some of the things she had been afraid to say before. After this her symptoms improved and she was able to deal reasonably with her problems.

The chief value of histamine, Dr. Niver thinks, is that it gives patients an increased sense of self-confidence without lessening their sense of power to control themselves. This makes it possible for them to probe with the psychiatrist into the underlying feeling conflict which is causing their illness. Many mental patients, Dr. Niver pointed out, feel so unstable that they dread any psychiatric treatment. They

fear that any "tampering with their psychological defenses" will drive them completely insane. Narcosynthesis helps in some of these cases, but some patients even dread the so-called "truth serum."

Dr. Niver turned to histamine as an aid in such cases because of the mutual antagonism between this body chemical and another, adrenalin, or epinephrine. The latter chemical can activate an anxiety that some psychiatrists say is an actual neurosis. So using its antagonist to help neurotic patients seemed logical. Histamine is a powerful chemical and must be used carefully.

Heparin For Blood Pressure

➤ THE ANTI-CLOTTING chemical, heparin, is being tried cautiously in women who develop high blood pressure during pregnancy. This is the forerunner of dangerous convulsions. The ancient Greeks seeing a pregnant woman seized with a sudden fit thought it was due to a lightning thrust from heaven and gave it the name of eclampsia, meaning "a bolt from the blue."

The condition remains a mystery, although modern doctors can detect the early stage of the disease by watching the pregnant woman's blood pressure. When it goes up, the patient is usually promptly put to bed. What to do next has remained a problem because the cause of the condition is not known.

It is known, however, that the blood of women with this condition clots more quickly. The red blood cells tend to stick together and the small blood spaces in the liver and placenta seem to be blocked by clotting fibers.

This has led to the trial of the anti-clotting chemical, heparin. When this is injected for several days into the veins of women in the pre-eclampsia stage, many of the serious symptoms seem to improve, Dr. E. W. Page of the University of California Medical School has found.

The improvement lasts as long as the drug is given. But the drug seldom cures the condition completely for the blood pressure often remains high.

The new treatment has certain drawbacks. It is expensive. The patient requires constant attention day and night. And it is dangerous, although no harmful effects have been noted so far.

Salt For Hypertension

➤ MORE SALT in their food is the pleasant prospect for patients with the kind of high blood pressure doctors call malignant hypertension and kidney disease. The present trend of restricting salt rigidly in such cases has gone too far, in the opinion of Dr. Francis D. Murphy of Marquette University School of Medicine. He has reported to the American Foundation for High Blood Pressure that many patients are doing better when salt is added to their food, rather than restricted.

Dye Locates Tumors

➤ BRAIN TUMOR detection is possible by means of a radioactive dye that becomes concentrated in these abnormal growths and can be detected through skull and skin with a Geiger-Muller counter. This newest medical development in the use of atomic-pile by-products has been tried out successfully in a dozen cases at the University of Minnesota Medical School by Dr. George E. Moore, senior research

fellow of the U.S. Public Health Service.

It was already known that a dye called fluorescein has an affinity for tumorous tissue. To render it radioactive, Dr. Moore chemically tacked on some radioactive iodine, converting it into diiodofluorescein. Small, calculated quantities of this were injected into the veins of patients suspected of having brain tumors, who were to undergo operations.

In a short time the blood had been carried to their heads, where the counters detected the presence of the radioactive atoms. Some of the iodine was present all over the brain, but on the patients' heads there were certain spots where the counters ticked much more rapidly than they did elsewhere. This was taken as indicating the possible presence of a tumor beneath that spot on the skull.

Subsequent operations proved the radioactive spotting method to have been correct in a large proportion of the cases.

The method is not considered infallible, and is to be used only in connection with other methods of diagnosis. So used, however, it should eventually be helpful.

Virus Kills by Phosphorus Theft

➤ THE CHEMISTRY of death in a bacterium attacked by a much smaller virus particle is described by Dr. Seymour S. Cohen of the University of Pennsylvania school of medicine. Essentially, it's a theft of phosphorous.

The virus particle, which is tadpole-shaped, has in its makeup a phosphorous-containing compound, nucleic acid. The bacterium has two kinds nucleic acid, different from the one in the virus, as well as other phosphorous-containing substances. In a virus-infected microbe, the processes by which it normally made use of phosphorous it obtained from its environment were all shunted to the production of the kind of nucleic acid the virus wanted. The bacterium could not grow, and eventually died.

This might all be very comforting to observe in a germ; but Dr. Cohen reminded his hearers that essentially the same process happens to our own cells when they are invaded by the viruses of such diseases as smallpox, yellow fever and poliomyelitis.

Antibiotics Stop Plant Disease

➤ ANTIBIOTICS, like penicillin and streptomycin, not only kill germs attacking human beings and animals; they can be put to good use against plant diseases as well. Profs. Curt Leben and G. W. Keitt of the University of Wisconsin have used a still unidentified substance extracted from Streptomyces, source of streptomycin, in completely controlling the difficult diseases known as apple scab and early blight of tomatoes. When the leaves of the plants being studied were sprinkled to simulate rain, the substance, whatever it was, was not washed off. We may yet see whole orchards sprayed with drugs that we now think of as usable only in hospitals and sickrooms.

Protection Against Weed Killer: Birds Resist Rodent Poison

Progress Notes: 2,4-D, DDT, 1080

➤ CROP plants can be protected from harm by 2,4-D used for killing weeds by pre-planting treatment with powdered activated charcoal. The treatment is of especial value for crops that are set out as young plants already rooted.

The research was done as a joint research project for the U.S. Department of Agriculture and the Mississippi Agricultural Experiment Station by Drs. H. Fred Arle, O. A. Leonard and V. C. Harris.

2,4-D is frequently sprayed on fields to kill weeds before the crop is planted or set out. However, there may be enough of it left to do serious harm to chemically sensitive crop plants.

In the experiments sweet-potato sprouts were used. Part of them had their roots dusted with the activated charcoal powder before planting and the rest were left untreated as controls. The latter group suffered very high mortality when set out in the 2,4-D-poisoned soil, while the treated plants, though sustaining some losses, survived much better.

Triple Tropical Attack

➤ MORE than 2,4-D must be used on weeds in the tropics. It kills some but fails to harm others, so a triple attack must be used combining 2,4-D with another killer chemical known as pentachlorophenol and an aromatic oil left after gasoline refining. This triple-threat mixture has been developed by Dr. A. S. Crafts, a member of the agricultural faculty of the University of California at Davis, Calif., who has been studying tropical weed problems at the Puerto Rico Agricultural Experiment Station, Rio Piedras.

The mixture will kill anything green that grows, but it can be applied close to the ground in plantings of bananas, coffee trees, sugarcane and pineapples in such a way that it gets on the weeds but not on the leaves of the taller crop plants.

More Turpentine and Rosin

➤ MORE efficient extraction from Southern pines of the gum that yields turpentine and rosin is promised through a 2,4-D treatment developed by C. E. Ostrom and C. S. Schopmeyer of the Southeastern Forest Experiment Station, Lake City, Fla. They have dedicated U.S. patent 2,435,724, recently issued on their discovery, to the American public for its free use.

The treatment consists simply in spraying the cuts made through the bark of the trees with a dilute solution or suspension of 2,4-D or one of its compounds. In tests conducted here, yields from treated trees were from two to seven times higher than those from similar trees that were merely slashed and not sprayed.

Eagles Safe From 1080

➤ THE SENSATIONALLY successful poison for rats and other vermin,

called 1080, appears to be less toxic to certain kinds of flesh-eating birds than it is to mammals. This is a matter of considerable practical importance, since 1080 is used in control operations against small rodents that swarm on western range-lands, and also against coyotes; and useful predatory and scavenger birds might suffer secondary poisoning by picking up such poisoned animals, or by finding poisoned meat baits left for coyotes.

In tests conducted by the U.S. Fish and Wildlife Service, eagles survived doses of 1080 that were 22 times larger than the amount fatal to coyotes. Buzzards ate "unlimited quantities" of meat dosed with 1080 in five times the concentration customarily used on coyote baits. Magpies seem to be the only meat-eating birds likely to be endangered.

Baits of poisoned grain intended for rodents on the range are now dyed with bright colors. It has been discovered that seed-eating birds practically never touch grain of these "wrong" colors. Most of the lower mammals, including the rodents, seem to be color-blind; at any rate they pick up the poisoned grain without hesitation, no matter what its color.

DDT Given Selective Action

➤ THE INSECTICIDE DDT, can be prevented from killing bees and other beneficial insects, without losing its deadliness for leaf-chewing caterpillars and other pest species, simply by coating its grains with a substance indigestible to the former class but digestible to the latter.

This ingenious method for making the action of DDT selective instead of indiscriminately toxic has been developed by a four-man team of scientists on the staff of a leading British pest-control firm. They are: W. E. Ripper, R. M. Greenslade, J. Heath and K. Barker.

The walls of plant cells are made up partly of substances known technically as hemicelluloses. Leaf-eating insects can digest these, but such highly specialized feeders as bees, flies and the tiny wasps that destroy other insects and their young are either unable to swallow such solid material or to digest it if they can get it down.

The four researchers made up a coating for DDT grains out of acid-treated cellulose. Honey-bees, blow-flies and parasitic wasps were harmed little or not at all by contact with this coated DDT, but cabbage-worms and leaf-roller caterpillars died after eating leaves upon which it had been sprayed.

Cooking Doesn't Destroy DDT

➤ BEEFSTEAKS and roasts from steers whose feed has been contaminated with DDT will have DDT in their meat. And this DDT will not be destroyed by cooking.

Since DDT in sufficient quantity is poisonous to human beings, this is a matter of some practical concern.

This discovery that DDT can get into meat by way of the animals' feed was made by a quintet of U.S. Department of Agriculture scientists.

Beef animals which had been fed DDT along with their regular rations were slaughtered and put into cold storage. Later the carcasses were butchered and the meat was prepared by several different methods of cook-

ing. Analyses for DDT were made on both raw and cooked meat. The results, the researchers state, "Indicate that the DDT in the beef was not materially decomposed or lost during the cooking."

Cattle can get DDT under ordinary feeding conditions either from spray or dust drifting onto their pasture from nearby fields or orchards, or by eating such things as alfalfa hay or corn stover that had been sprayed during growth as protection against insect pests.

Members of the research team were: R. H. Carter, P. E. Hubanks and H. D. Mann of the Bureau of Entomology and Plant Quarantine and Lucy M. Alexander and Grace E. Schopmeyer of the Bureau of Human Nutrition and Home Economics.

Synthetic Latex and 2,4-D

► 2,4-D KILLS plants more quickly and surely when it has the help of a synthetic-plastic latex known by the trade name of Geon 31X, it has been discovered in experiments at Michigan State College, East Lansing, Mich., by Drs. C. L. Hamner and Kiang Chi-Kien.

Kidney-bean seedlings were treated with the sodium salt of 2,4-D by dipping leaves into solutions of various strengths, from five to five hundred parts per million. Some of the plants were subsequently sprayed with the latex, while the rest were left unsprayed, as controls.

All the plants treated with the strongest solution of 2,4-D died, but those treated with weaker solutions and left unsprayed with the latex recovered and continued growth, after greater or less evidence of poisoning. But mortality in the plants treated with both weak 2,4-D solution and the latex spray was very high.

Then the treatment was tried on oat seedlings, which normally are not affected by 2,4-D, since they belong to the grass family. However, while those that received only 2,4-D showed no ill effects, those that were afterwards sprayed with the latex died as the bean seedlings had done.

The two experimenters do not know what the latex spray does to make the 2,4-D more effective, but suggest that by forming a covering film it may insure greater penetration of the tissues.

Cotton Badly Injured

► COTTON SEEMS to be one of the most sensitive of all plants to the weed-killing chemical 2,4-D, so when 2,4-D was dusted on water hyacinth and rice-field weeds in Louisiana last summer some sensational damage was done to neighboring cotton fields by dust that drifted to where it had no business to be.

Among the symptoms of 2,4-D, injury observed by Prof. Clair A. Brown of Louisiana State University were leaves with abnormally long points and ruffled margins, malformed flowers with dwarfed petals grown together, and worst of all a premature dropping of buds and flowers with corresponding reduction in yield. Losses of as much as 60% of the crop were reported.

Formaldehyde is used in large quantities to harden certain plastics.

For The Home Lab

Electro-Chemistry - II

Electrolysis — (Part 1)

by Burton L. Hawk

➤ We have discussed the formation of an electric current as a result of chemical reaction (Chemistry, April 1948); now we will investigate the effect an electric current has on chemical compounds.

This is not a novel idea. Sir Humphrey Davy thought of it more than one hundred years ago. His research in the field of electro-chemistry was highlighted by the isolation of the alkali metals. After several unsuccessful attempts to decompose aqueous potash solutions with an electric current, Davy used potash in igneous fusion. When an electric current was passed through the compound, amazing things began to happen. There was violent effervescence throughout with the formation of small globules, or in Sir Davy's own words:

". . . . at the negative surface, there was no liberation of elastic fluid; but small globules having a high metallic lustre, and being precisely similar in visible characteristics to quicksilver, some of which burnt with explosion and bright flame as soon as they were formed, and others remained and were merely tarnished and finally covered by a white film which formed on their surfaces."

We can well imagine how excited and joyous Sir Humphrey Davy must have been. Here was a new powerful force — the electric current. How would it react on other substances? Could additional elements be isolated? Indeed they could, for following in rapid succession sodium, barium, strontium, calcium, magnesium and lithium were isolated by means of the electric current. And using the sodium and potassium prepared by electrolysis the elements zirconium, titanium, cerium, thorium, beryllium, boron, silicon, and aluminum were isolated.

Source of Current

But let's get back to the home lab. Of course, a direct current is required for these experiments. Three or four dry cells may be used or two 3-volt "utility" batteries. The storage battery from the family automobile is also satisfactory. If you have access to alternating current, you may use a rectifier or battery charger to convert the alternating to direct. If you use dry cells, connect them in series, that is, the positive terminal of one cell to the negative of the other. For the electrodes, use small carbon rods. Pencil leads will serve very nicely in this capacity.

Aqueous Sodium Chloride

Let us briefly consider a solution of sodium chloride. We have positively charged sodium ions and negatively charged chloride ions migrating throughout the solution. In addition the water provides a small quantity

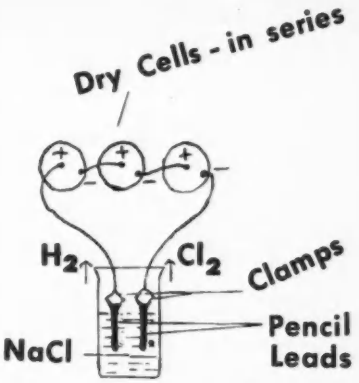
of ions—positive hydrogen and negative hydroxol. To summarize, the solution contains Na^+, Cl^-, H^+, and OH^-.

When the two electrodes from a source of electricity are immersed in this solution, what happens? Well, as you might expect, the positively charged ions (Na^+, H^+), are attracted to the negative electrode and the negative ions (Cl^-, OH^-) to the positive electrode. The hydrogen ion removes an electron from the negative electrode and thus becomes a hydrogen atom. The sodium ion, however, is much more reluctant in accepting electrons and will not do so unless forced to by a greater current of electricity.

Meanwhile the negative ions (Cl^-, OH^-) are moving toward the positive electrode. Here the chloride ion loses an electron and becomes a chlorine atom. The more selfish hydroxol ion will not readily give up its electron and hence remains in solution 'status quo.'

Now we have hydrogen released at the negative and chlorine at the positive. The sodium and hydroxol ions remaining in solution combine with each other forming a solution of sodium hydroxide.

To demonstrate the above, simply electrolyze a salt solution to which a few drops of phenolphthalein solution have been added. Almost immediately the solution will turn pink indicating the presence of sodum hydroxide. (If your salt solution turns pink upon addition of phenolphthalein before electrolysis, use potassium chloride or chemically pure sodium chloride. This alkaline reaction is probably due to the presence of magnesium carbonate added to table salt to keep it "pouring when it rains."). As electrolysis is continued you will be able to detect the odor of chlorine. Some of the chlorine dissolves in the solution and reacts with the sodium hydroxide forming sodium hypochlorite:



➤ Apparatus *set-up for experiments with electrolysis.*

$$2NaOH + Cl_2 \rightarrow NaCl + NaClO + H_2O.$$

This mixture of salt and sodium hypochlorite is known as *Javelle Water*, sold commercially as a bleach for the home laundry. It is also useful as an antiseptic, sodium hypochlorite being an efficient bactericidal agent.

Thus with salt solution as our starting point, we obtain hydrogen, chlorine, sodium hydroxide, sodium hypochlorite, and Javelle Water.

Keep your battery set-up handy. We will continue with more electrolysis experiments next month.

Materials, Processes and Machinery Among Latest Chemical Inventions

Chemical Patents of the Month

Copies of complete specifications may be ordered from the Commissioner of Patents, U. S. Patent Office, Washington 25, D. C. Order by patent number and remit 25 cents for each patent, by money order or Patent Office coupon, not stamps.

Uranium From Low-Grade Ore

➤ URANIUM, source of atomic energy, is now obtainable from low-grade domestic carnotite ores, by a new process on which U. S. patent 2,442,429 has been issued to two Ohio State University chemists, Dr. Ralph D. Nye and Prof. Dana J. Demorest. Release from dependence on overseas sources of higher-grade uranium ore might prove exceedingly important to American economy and security.

In the new process, the finely ground ore is first treated with a hot solution of caustic soda or potash. This dissolves the three valuable metals present in carnotite: uranium, radium and vanadium — the latter important in metallurgy. The dark, slimy solution is washed free of the worthless sandy mineral matrix of the ore by upward currents of water.

Then sulfuric acid is added to the solution, followed by the addition of barium chloride or other metallic salt. This precipitates a dark sludge which contains most of the vanadium; this can be removed and processed as an ore concentrate to obtain that metal. The clear liquid remaining, which contains the uranium and radium, is again treated with caustic alkali solution, which brings down a precipitate containing the valuable uranium and radium in concentrated form.

Glass as Carrier

➤ FOR CONVENIENCE of handling radium and other radioactive materials in research and industrial applications, Solomon Rosenblum of Princeton, N. J., incorporates it in glass. The radioactive material is laid on the surface of a glass plate, sandwiched between two metallic plates. An electric current simultaneously heats the glass (which increases its conductivity) and incorporates the material into its substance. After cooling, the glass is ready for use as a source of radiations and as an air ionizer.

Patent 2,442,617, granted on this invention, has been assigned to the Canadian Radium and Uranium Corporation.

Portable Dehydrator

➤ INSTEAD OF carrying vegetables and fruits from field and orchard to the dehydrating plant, Harry D. Curtis of Fond du Lac, Wis., proposes to carry the dehydrator to the field or orchard. His patent, 2,442,344, covers a portable machine mounted on a trailer chassis, with a heater-blower delivering currents of drying air through the dehydrator's perforated floor.

Saves Copper on Shells

➤ ONE OF THE really serious wastes of war is the amount of copper literally

shot away as rotating bands to enable rifling lands to put spin on shells. A new effort to find a workable substitute for scarce copper is represented in patent 2,442,369, assigned royalty-free to the government by the inventor, Maj. Edward T. McBride of the U. S. Army. His rotating band is a hollow tube of a plastic filled with some other soft metal such as lead or aluminum.

Insect Ammunition

➤ WARFARE on a different front — against the insects — is the concern of patent 2,442,652, granted to Theodore W. Kerr, Jr., of Seymour, Conn., and Walter D. Harris, Naugatuck, Conn. It renders DDT more effective by adding allyl 2-naphthyl ether. Patent rights are assigned to the United States Rubber Company.

Fibers Stand on End

➤ STATIC ELECTRICITY, the same thing that sometimes makes your (or your cat's) hair stand on end when you brush it, is put to industrial use in a new textile process on which U. S. patent 2,442,880 has been granted to Aaron Schwartz of New York, assignor to the Celanese Corporation of America.

Jumbled fibers of cellulose acetate or other synthetic textile materials are discharged from a hopper between two smooth-surfaced moving belts which are kept charged with static electricity. This "stands them on end lengthwise," giving them a neat parallel arrangement in preparation for further processing. The bothersome carding or combing process, which breaks many fibers and wastes some, is eliminated.

New Electron Microscope

➤ A NEW dual-function electron microscope, useful in both basic research and industry, is offered by Dr. James Hillier of Cranbury, N. J., RCA Laboratories physicist, for patent 2,443,107. The electron beam, before striking the specimen under examination, is passed through two annular magnetic "lenses," the second of which can vary its focus through variations in the strength of its field.

At one focus, a sharply outlined, highly magnified image of the specimen is projected on the fluorescent screen or the photographic plate. Then the focus can be changed to project a diffraction pattern, which tells the material's molecular and atomic make-up. Hitherto this has required two manipulations of the specimen, perhaps on two separate instruments, with no assurance that the two "shots" represented exactly the same portion of it.

DDT Booster

➤ DDT IS COMBINED with a less-known insecticide, cyclohexyldiphenyl ether, in the invention on which patent 2,442,760 was obtained by two Dow Chemical Company researchers, Curtis E. Dieter and Bernard J. Thiegs, both of Midland, Mich. They claim for it a much greater efficiency against certain insects than is obtainable by either compound alone.

Antibiotic Patented

➤ A RECENTLY isolated antibacterial substance is the subject of patent 2,443,485, issued to Dr. Selman A. Waksman of Rutgers University, discoverer of streptomycin, and Dr. Harold B. Woodruff, Merck and Company microbiologist. The new

antibiotic is known as streptothricin. Patent rights are assigned to the Rutgers Research and Endowment Foundation.

Geiger Counter Servicing

➤ ANOTHER INVENTION in the atomic-energy field is protected by patent 2,443,365, assigned to the Atomic Energy Commission by the inventor, Ernest H. Wakefield of Chicago. It is on a new method for mounting Geiger counter tubes, which permits their easier withdrawal from the shield, for replacement or servicing.

Sweet-Potato Starch

➤ SWEET-POTATO starch of superior quality can be produced in four hours, as against the 72 required at present, by a new process on which U. S. patent 2,443,897 has been issued to Gregory M. Dexter of Scarsdale, N. Y. and Dr. Francis H. Thurber of New Orleans.

Principal advance in the new method is in the mechanical handling of the roots. They are first sliced thin by machine, then grated to a fine pulp. Lime water is added to precipitate out the pectin and harden the fiber, and first separation of the starch takes place in a centrifuge. Further sieving of the starch-milk is carried out through a series of fine screens.

By cutting down the time and eliminating the use of starch tables and settling tanks, the new process does away with old troubles from molds and fermentation bacteria, which would often quite literally "gum the works," and also injure the quality of the final product.

Rights in the patent have been split, Dr. Thurber assigning his share to the U. S. Department of Agriculture and Mr. Dexter assigning his to the United States Sugar Corporation.

Cold Gases Dehydrate

➤ DRYING PROCESSES, whether for dehydrating foods or finishing printed or photographic materials, cannot always be carried on to advantage with the use of heat, because high temperature sometimes injures the product. A woman inventor, Esther R. Elder of Pasadena, Calif., gets around this difficulty by using liquefied gases, such as carbon dioxide, warming them up sufficiently to return them to gaseous form though still leaving them cold, and passing them over the materials to be dried while they are at low temperature but completely dry. She has received patent 2,443,610 on this process.

New Twist to Old Invention

➤ ONE OF THE oldest inventions in the world, the Archimedean screw, is given a new twist in the invention on which patent 2,444,000 has been awarded to R. R. Younger of San Francisco. Archimedes, it will be recalled, lifted fluids, or boosted them along their course, by means of a long screw turning in an open-ended tube. In Mr. Younger's apparatus, the ends of the tube have conic closures, the screw, which has an increasing pitch, is firmly attached to the casing, and the whole is spun rapidly by means of a motor. Passage of the fluid is thus speeded.

Fluorination Technique

➤ Two Purdue University chemists, Prof. Earl T. McBee and Dr. Zara D. Welch, have received patent 2,443,630 on an improved method for substituting atoms of fluorine for one or two of the chlorine atoms of carbon

tetrachloride, to make liquids useful as solvents and refrigerants. The process involves use of a pressure of 750 pounds per square inch, at a temperature above 300 degrees Centigrade. Patent rights are assigned to the Purdue Research Foundation.

Electrical Precipitation

➤ AN IMPROVED electrical precipitation apparatus for cleaning dust, pollen grains and other particles out of the air is the subject of patent 2,443,780, issued to H. A. Wintermute of Plainfield, N. J., and assigned to the Research Corporation. The air is passed through a honeycomb of metallic conduits, the walls of which are kept charged with particle-pulling static.

Cooks TNT Out of Shells

➤ STATESMEN may be a bit slow about beating swords into plowshares, but a civilian employee of the Army, Cedric A. Hoskin of Succasunna, N. J., has devised an improved method for getting TNT, PETN or other high explosive charges out of shells, for possible use as blasting powder.

It consists simply of a grid of steam pipes, each one with a row of discharge vents over which the opened shells are set. The steam blast melts out the high explosive, which trickles into a sloping-bottomed tank below, kept full of cold water. The trickling, tar-like explosive forms into firm pellets, which are raked out through an opening at the lowest part of the bottom, dried, and prepared for other uses. The empty shells, of course, are high-grade steel scrap.

Rights in the patent No. 2,444,045, have been assigned royalty-free to the government.

Hydrogen Chloride

➤ A SIMPLE but efficient method for the production of hydrogen chloride, highly important industrial compound, is the subject of patent 2,444,256, assigned to the Shell Development Company by Earl S. Hill of Albany, Calif. Hydrogen and chlorine gases are burned together in a closed vessel, while previously fabricated hydrogen chloride is introduced to control the temperature.

Paper From Reeds

➤ PAPER, which gets its name from the marsh reed, papyrus, from which it was first made, is again made from marsh reeds in the process on which L. D. Jordain of Princeton, Ill., has obtained patent 2,444,047. The reeds are first crushed, then treated with quicklime to form the pulp into a loose mat of paper fiber.

Low-Cost Barium Chloride

➤ A LOW-COST method of making barium chloride, an important chemical reagent widely used in industries, was revealed by the University Department of Chemical Technology at Bombay, India. The process uses as raw materials the mineral barytes, which is barium sulfate, and magnesium chloride, perhaps the cheapest source of chlorine.

The method involves the roasting of barytes with wood charcoal, powdering the resulting mass, and heating the pulverized material with a 46% to 47% magnesium chloride solution at less than 100°C.

Atomic Energy Commission's Report Summarizes Isotope and Power Progress

Atomic Energy Today

The following excerpts from the Atomic Energy Commission's Fourth Semi-Annual Report, just published, outline the progress of advances in atomic energy research. They state the problems of research using pure isotopes to trace the course of a given element through the rapid transitions of life processes, and describe the surprising new knowledge which is being found through these researches. The more distant goal of obtaining power from atomic reactions is discussed also, and new information on the many problems this project brings up is revealed. The complete report, with a detailed list of the research projects now using pure isotopes, may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

Isotopes[1]

▶ Isotopes for scientific, medical, agricultural, and industrial use constitute the first great contribution of the development of atomic energy to peacetime welfare. Industrial power from nuclear energy may be a decade or longer in the future and most other applications are still largely speculative. But isotopes produced in the Nation's atomic energy establishment at Oak Ridge, Tennessee, are already at work in more than 300 laboratories and hospitals in this country and abroad, adding to man's store of knowledge about himself and the world around him.

Isotopes assist science in two ways: as *sources of radiation* for many potentially important uses including the treatment of disease and as *"tracers"* of processes formerly difficult or impossible to observe. As tracers, they are proving themselves the most useful new research tool since the invention of the microscope in the 17th Century; in fact, they represent that rarest of all scientific advances, a new mode of perception.

[1] There are differing kinds of atoms called *isotopes*, in nearly all of the chemical elements (hydrogen, oxygen, carbon, iron, copper, etc.). The atoms of any chemical element are all alike in their chemical behavior—the way they combine to make all material things. Most elements, however, have atoms that are not alike in their nuclear properties. For example, every copper atom has 29 electrons whirling about its nucleus, and it is this number (the *atomic number*) that makes copper behave the way it does chemically. But the nucleus of some atoms of copper contains a total of 63 particles (29 protons and 34 neutrons), while the nucleus of other atoms of copper contains 65 particles (29 protons and 36 neutrons). Since these two kinds of copper atoms have different numbers of neutrons in their nuclei, they have different *atomic weights*. They are the two natural or "stable" isotopes of the element copper.

Copper atoms can be made, in nuclear reactors and in cyclotrons, which have nuclei containing some other number of neutrons than 34 or 36. These artificial nuclei are unstable. Any one of them sooner or later converts itself into a stable nucleus by giving off particles and energy rays. These artificial "unstable" copper atoms are called the *radioisotopes* of copper. The radiations from the radioisotopes of the various elements are all different, but they all are able to penetrate solid matter to a greater or less degree.

Man's conquest of nature has generally followed the pattern of (*a*) observation, (*b*) understanding, and (*c*) control. The microscope and the X-ray machine have brought into view the cells and organs of living bodies, the molecules and crystalline structure of matter. But until recently man's vision has not penetrated into the details of growth and change in the living cell or the intricate chemistry of the molecule.

Now, using tracer isotopes, the scientist and engineer can observe atoms as they take part in basic organic and inorganic reactions, much as though the atoms were visibly tagged or labeled. For the first time, it becomes possible to follow in intimate detail nature's fundamental processes—such processes as:

Photosynthesis, in which green plants use energy from the sun to form sugar, starch, cellulose, and other energy-containing carbon compounds used by man;

Metabolism, in which some of these carbon compounds, taken into the body as food, give the sun's energy to the living cell;

The chemistry of hydrocarbons, in which other carbon compounds —coal, oil, gas—that provide man with industrial fuel energy are processed into gasoline and other materials that serve his purposes.

New as it is, tracer research has already broadened our understanding of these and many other fundamental processes of nature. Already, medical men are profiting from a better understanding of the working of the human body. For the future, it is difficult to forecast the gains that isotopes will bring. They will speed the battle against disease. They will help man to make more efficient use of nature's materials, to grow more food, to produce better manufactured goods —in short, to adapt his environment to his needs.

All told, the 96 known chemical elements have more than 800 isotopes, stable and radioactive. Carbon, for example, has five isotopes; that is to say, there are five different kinds of carbon atoms all chemically the same because their nuclei carry the same electrical charge. Where they differ is in their weight. The five kinds of carbon atoms weigh approximately 10, 11, 12, 13, and 14 times as much as the fundamental hydrogen nucleus. The variation in the numbers of neutrons in their nuclei, which causes these weight differences, is also responsible for differences in stability. Two of the carbon isotopes are natural and "stable," three are man-made and "radioactive."

Stable Isotopes

The two natural isotopes occurring in ordinary carbon are carbon 12 and carbon 13 ("C 12" and "C 13"). Of each 100 carbon atoms found in nature, 99 will be C 12 and one will be C 13. This is true whether you find the carbon in the starch in a potato, the glycogen in the liver, or the coal underground; in the graphite in a pencil, the steel in a knife blade, or the diamond in a jeweler's window.

During the 1930s, physicists succeeded in processing a few of the lighter elements so as to "enrich" them in their rarer isotopes. They produced carbon, for example, that contained 20 per cent and more of C 13, which was consequently slight-

ly heavier than natural carbon, although chemically the same.

The physicist's success in producing "heavy hydrogen," "heavy oxygen," "heavy nitrogen," and "heavy carbon" was welcomed by the biologist. All of these elements enter importantly into life processes. Carbon compounds, for example, not only provide animals with energy but also enter into flesh, and blood and bone.

Yet investigators had always been baffled by such a basic problem as finding out how much of a given batch of carbon atoms taken into a living body went into fat, starch, protein, or intermediary compounds and how much went to build bone, flesh, or blood. By chemical analysis they could extract, purify, and weigh the quantities of carbon in a dissected rat, but all carbon was chemically alike, so the biologists could not say that this or that portion of the carbon had come from any particular batch of food. In other words, before tracers were available, the biologist found it impossible to observe and understand in detail how carbon or other food elements are used by the body.

Given carbon, however, that was enriched in C 13, he could perform a tracer experiment. Feeding to a rat a sample of sugar made with this heavy carbon, which behaves in the body exactly like any other carbon, he could dissect the rat after a measured interval, extract and purify such samples of carbon as he was able to handle, and learn how much of the sugar "tagged" with C 13 had gone into the make-up of each sample. In many parts of the animal the tagged carbon was too much diluted for analysis, and therefore the picture of its distribution was incomplete. But the availability of the isotope provided what had been totally lacking before: a method of identifying portions of a specific batch of atoms, even after they had gone through chemical changes, and learning something about where and how they had been used by the body at the end of a chosen interval of time.

Radioactive Isotopes

Also in the 1930s, while some physicists were learning to separate (or concentrate) the stable isotopes, others discovered how to manufacture radioactive isotopes that do not occur in nature. C 11 and C 14, for example, are man-made carbon atoms which are just as truly carbon in the chemical sense as C 12 and C 13. But the unnatural number of neutrons in their nuclei makes them unstable. They decay into stable elements (C 11 into boron; C 14 into nitrogen) and in so doing send out radiations from their nuclei.

The radioactive isotope puts nuclear energy at the service of the investigator and thus tremendously increases his power of perception. When tagged with C 14 the batch of carbon in the sugar fed to the rat can be detected in the dissected tissues no matter where it occurs in the body or what chemical form it takes. Minute amounts of the tagged carbon reveal their presence to electroscopes or Geiger counters by the radiation signals they emit. In the typical Oak Ridge shipment of C 14—a millicurie[2]

[2] A *curie* is arbitrarily taken as that amount of a radioactive material that disintegrates at a rate equal to that of one gram of radium, that is, about 37 billion disintegrations per second. A *millicurie* is one-thousandth (.001) of this amount; a *microcurie* is one-millionth (.000001).

—37 million atoms are distintegrating every second. This amount of C 14 is contained in a mere pinch (one three-hundredth of an ounce) of barium carbonate, the compound in which C 14 is usually supplied to users. Yet, if this quantity were distributed among a million rats, the radioactivity would still be detectable in each. The experimenter therefore may allow for extreme dilution of his tracer material in the processes he studies. In the terms of the scientist the radioisotope offers the same *specificity* as the stable isotope (the means of identifying a specific batch of material); and it adds to this an almost incredible *sensitivity*—a sensitivity millions of times greater than any analytical technique has ever before provided.

Furthermore, some radioisotopes have given the experimenter the additional advantage of *detection at a distance* of his tracer material. In qualitative observations he need not always end the experiment—dissect the rat or cut up the plant—to make his observations. Because many radiations penetrate solid matter to a practical degree, it is possible for the scientist to carry on continuous observation of life processes in plants or animals. Radioactive atoms have been called laboratory "spies," since they accompany groups of natural atoms through long series of chemical and biological adventures and report all along the way the whereabouts and the size of the groups of which they are a part.

Generally speaking, the signals sent out by radioisotopes can be readily distinguished one from another. The radiation of C 11, for instance, is very penetrating or "hard," that of C 14 very "soft." The intensity of the radiation of a given element, depending upon the rate at which its atoms transform into the stable state, is directly related to its effective life or "half-life,"[3] to name the unit in which this rate of decay is measured. The half-lives of the elements are determined by their nuclear compositions, and nothing that man does can lengthen or shorten them by as much as an instant. C 11, with its intense radiation, has a 21-minute half-life. This naturally limits its usefulness for most investigations. C 14, on the other hand, has a half-life of 5,100 years. Most half-lives of the radioisotopes lie somewhere between these extremes, although a few, like that of C 10 (nine seconds), are so short as to rule the isotopes out as research tools.

Finally, in addition to *specificity*, *sensitivity*, and *detectability*, radioisotopes offer to scientists today the even greater benefit of unprecedented *availability*. Before the war, cyclotrons produced them in microcurie quantities—invisible to the eye; and some varieties, like C 11, must still be made in particle accelerating machines. But the war-created chain-reacting pile produces C 14 in quantities millions of times greater than had been possible before, and the same is true for most of the important radioisotopes

[3] The *half-life* of an isotope is that period in which the radioactivity decreases to one-half of its original value—the period in which one-half of the radioactive atoms will disintegrate. In the next similar period, one-half the remainder of the unstable atoms will disintegrate, leaving one-fourth. In a period equal to three times the half-life, the remaining radioactivity will be one-half times one-half times one-half, or one-eighth.

used in research and the treatment of disease.

The scientific and medical work possible with radioisotopes today is limited primarily by the number of trained workers capable of using them.

Projects With Isotopes

Recently several hundred of the users of Atomic Energy Commission isotopes reported briefly to the Commission's Isotopes Division on the projects they now have under way. . .

Projects with carbon 14 are illustrative. All told, those reporting tell of 72 different uses of carbon 14, which provide a representative sample of the more than 185 projects now under way throughout the world using this isotope.

Some of the reports tell of investigations of various phases of photosynthesis—of attempts to determine, for example, what compounds are first formed by green plants out of sunlight, water, and carbon dioxide; where these compounds are distributed in the plant; how they are built up into the more complex molecules of the food we eat; which plants tend to produce energy-rich compounds in their early stages of growth (a question of practical interest to cattle feeders); and so on.

At least 40 of the reports recount studies of the way in which these compounds figure in the metabolism of living bodies. These studies are carried on by labeling with C 14 the sugars, starches, glucose, proteins, vitamins, and other substances eaten by men and animals.

Seventeen of the studies are concerned with following the chemical transformations of carbon compounds in industrial processes, such as the "cracking" of petroleum, the processing of metals, and the use of the Fischer-Tropsch process for the manufacture of petroleum out of coal.

A Thousand Projects

Carbon 14 is only one of 100 varieties of radioisotopes now being distributed from the Oak Ridge atomic furnace and accounts for less than one out of ten of the total shipments. Many of the others are of equal or greater importance in particular fields —radioactive iodine and phosphorus, for instance, in medical therapy; radioactive phosphorus, calcium, sulfur, and iron in fertilizer studies; and radioactive phosphorus, sulfur, calcium, cobalt, zinc, and iodine in cancer research. All told, more than 1000 different isotope projects are being conducted today, and they deal, in one way or another, with every important aspect of the physical welfare of mankind.

Pile Production of Isotopes

➤ BROADLY SPEAKING, there are three ways in which neutrons in the pile produce radioisotopes: (1) by splitting atoms of fissionable uranium into new atoms of entirely different elements — fission products, so-called — which are radioactive themselves; (2) by being captured in the nuclei of atoms of special "target material" inserted into the pile, turning them into heavier isotopes of the same element; (3) by altering the electrical charge of the nuclei of atoms of target material, thereby transmuting them into isotopes of a different element.

Uranium fission products removed

from the pile contain a great variety of radioactive materials, which — in method (1) above — can be extracted and purified by chemical means. However, the radioisotopes obtained are all those of elements near the center of the atomic scale between zinc (number 30) and gadolinium (number 64). With the exception of iodine 131, these do not now enter significantly into medical, biological, agricultural, or most industrial processes. Therefore, most of the radioisotopes supplied by Oak Ridge must be prepared by methods (2) and (3). These call for the preparation and pile irradiation of special target materials. Phosphorus 32, a widely used radioisotope, can be produced by both methods and may be used to illustrate.

In the production of phosphorus 32 by "neutron capture," method (2), phosphorus 31, contained in phosphate, is put into aluminum cans which are set in holes in a graphite block and pushed into the center of the pile. Each atom of the stable element phosphorus 31 that captures a neutron becomes phosphorus 32. But not enough neutrons are present in "low flux" piles to convert more than a small proportion of the phosphorus atoms to the radioactive state. Hence the phosphorus 32 is still much diluted with phosphorus 31, and the treated phosphate is not highly radioactive.

In practice, therefore, phosphorus 32 is usually produced by method (3), "transmutation." This process starts with a target element different from the element of which an isotope is desired. Sulfur is the target for the production of phosphorus 32. Bombardment by neutrons in the pile changes the electrical charge of the nuclei of some of the sulfur atoms, and thus transmutes them into phosphorus 32. When the sample has been removed from the pile, the radioactive phosphorus can be chemically separated from the target sulfur. Phosphorus 32 in a very pure form, high in radioactivity, can thus be obtained. Unfortunately many important radioisotopes—those of calcium, iron, and zinc, for instance—cannot effectively be made by transmutation. They can be produced only by neutron capture, and this, as stated above, gives a product low in radioactivity. When a pile of higher neutron flux becomes available, it will be possible to produce radioisotopes of greater usefulness for research.

From the preparation of the target material to the final shipment of the product, the production of radioisotopes demands skilled personnel and special equipment. When the pile is shut down for the removal of the irradiated samples, each member of the team of workers must know precisely his assignment in the operation and carry it out quickly and without error. Geiger counters and other radiation detection equipment must be used constantly to check the radiation present. In subsequent chemical treatment of materials, the work must be carried on behind lead shields, the workers using tongs and mirrors to avoid exposure. Many chemical operations are conducted inside a "hot lab," a room with thick concrete walls in which apparatus is manipulated from outside by remote control devices, the chemist viewing his work

through periscopes. Each radioisotope, moreover, is a separate production problem, involving its own combination of requirements--for target material, irradiation time, chemical treatment, safety precautions, and the rigid time limits associated with its inflexible half-life.

Dynamic Life Processes

➤ TRACING life processes by the use of stable and radioactive isotopes, we now have learned that all components of the body—the muscles, bones, and teeth as well as the blood, secretions, and food stores—are in a constant state of breaking down and renewal. The multitude of life compounds involved in this process go through continuous and rapid chemical reactions, many of them reversible. Those not serving at any given moment as part of the fixed structure, and not excreted from the body, are combined into a metabolic "pool" of life ingredients available for use anywhere in the body.

The most surprising fact revealed has been the extreme rapidity with which life processes take place. Experiments with radiosodium provide a measure of their speed. By "tagging" salt (sodium chloride) with sodium 24 and injecting it into the human body, investigators have found that salt is diffused through the walls of the veins, transported to the sweat glands, converted into sweat, and carried to the surface of the body, all in less than one minute's time. Again, it has been discovered that the transfer of fluid in and out of the human veins is so rapid and continuous that it carries back and forth with it 50 pounds of salt, on the average, every day.

Rapid as they are, however, the biochemical reactions which build up and break down living tissue are so delicately regulated that every part maintains its characteristic form and composition, every fluid its particular chemical make-up; and the total volume of all bodily ingredients remains constant. Although metabolic changes are continuous everywhere, the parts of the body, in health, always appear the same. Hence the classic concept of the body as a mechanical engine.

A modern tracer investigator has compared the body, instead, to a military regiment, which retains its size, form, and composition while the individuals of which it is composed are continually changing: joining up, being transferred from post to post, promoted, or demoted; acting as reserves; and finally departing after varying lengths of service.

Since the treatment of illness must be based upon an understanding of the normal functioning of the body, the medical implications of the new concept of the "dynamic state of body constituents" are nothing less than revolutionary. Fundamental changes in medical science are certain to result from research with isotopes. But isotopes assist the medical research scientist and the physician in more immediate ways as well. They are the most powerful and searching laboratory tools yet devised for the investigation of the functioning and malfunctioning of particular organs; for studying the action of vitamins, hor-

mones, enzymes, and other biochemical substances; and for testing the efficiency of many kinds of treatments. Furthermore, they are of practical assistance in hospitals for diagnosis and therapy.

Kinds of Tracer Research

Virtually no observation was possible of the mechanisms, reactions, and pathways of elements and compounds in the body before isotopes were available to trace them. The hundreds of different life materials—those built into the structural parts and those in the metabolic "pool"—are indistinguishable as to orgin. The almost limitless variations of the basic carbohydrates, fats, and proteins are formed out of relatively few source elements in the diet—carbon, nitrogen, hydrogen, oxygen, phosphorus, sulfur, and iodine. Long before isotopes were available, biologists had attempted to trace some of these elements by labeling them with benzine derivatives, dyes; and some identifiable materials, but the very abnormality of the substances used upset the delicate processes being studied and therefore produced confusing results.

Today isotopes provide labels for all the fundamental life elements—labels which the body cannot distinguish from the normal material. Biologists have already used them to trace such a variety of bodily ingredients as: alcohols, amino acids, antigens, bacteria, bile acids, blood cells, carbohydrates, carcinogens, enzymes, fats, fatty acids, hormones, insulin, nucleic acids, penicillin, pharmaceutical agents, proteins, starches, sulfa drugs, tissue fluids and salts, viruses, and vitamins.

So small are the quantities of radioisotopes required for tracer experiments that most of them can safely be employed in normal human bodies. Calcium 45 and strontium 89 and 90, because they have long half-lives and tend to remain in the body, are at present important exceptions.

Isotopic tracers permit two kinds of biological analysis: *qualitative*, in which a particular element introduced into an experimental animal, and sometimes a human subject, may be followed wherever it goes, whatever chemical form it takes, and *quantitative*, in which the amount of the tagged element in a tissue or fluid may be measured with unprecedented delicacy. When these two methods are combined, formerly insoluble biological problems, such as the rate of turnover of nutrient materials in different kinds of cells, may be successfully tackled.

Particle Accelerators[4]

➤ THE POSTWAR assault of the physicists upon the citadel of the atomic nucleus is being mounted with new and heavier artillery. The number of particle accelerators—cyclotrons, synchrotrons, betatrons, linear accelerators, etc.—in operation in 50 U. S. laboratories and at least 10 abroad will be more than doubled by construction that is already scheduled.

[4] Cyclotrons, synchotrons, and betatrons are particle accelerators employing large electromagnets to hold the paths of the particles being accelerated in closed or spiral orbits. These machines are to be contrasted with accelerators not employing electromagnets in which the paths are straight lines, e.g., linear accelerators and Van de Graaff generators.

And at least two dozen of the new atom smashers will be capable of bombarding the nucleus with particles accelerated to more than 100 million electron volts—an energy produced by only a single machine today.

The Commission's particle accelerator program has been marked by two important events in 1948. The meson, a primary nuclear particle, was artificially produced and observed in the laboratory for the first time in the giant 184-inch synchrocyclotron operated with AEC funds in the Radiation Laboratory of the University of California at Berkeley; and plans were completed by the contractors and staff of the Commission for the construction of two new multi-billion-electron-volt proton synchrotrons, many times more powerful than the present Berkeley machine.

The Meson

On February 21, workers in the Berkeley Radiation Laboratory achieved one of the major objectives of modern research in nuclear physics: they recorded on photographic emulsion plates placed within the 184-inch cyclotron the presence of mesons, hitherto observed only in cosmic rays. The meson (also called the mesotron) is an evanescent high-energy particle intimately associated with those fundamental nuclear processes that are still largely mysterious to scientists. When available under controlled laboratory conditions, the meson is expected to be an important tool for studying the nature of the forces that hold the nucleus together. Since the development of atomic energy must depend upon man's understanding of these nuclear forces, the laboratory production of the meson is regarded by many nuclear physicists as the most important advance since the discovery of uranium fission in the late 1930's.

Multibillion-Volt Accelerators

Before the meson can be understood and exploited as a laboratory tool, however, more powerful atom smashers must be built. The 184-inch Berkeley machine—the world's greatest at this time — possesses barely enough power to produce low-energy mesons. During the past year, physicists in the Commission's laboratories have been studying the feasibility of constructing electronuclear machines powerful enough to accelerate particles to energies of several billion electron volts. By the end of 1947, the Berkeley Radiation Laboratory and the AEC's Brookhaven National Laboratory on Long Island had completed the necessary theoretical work and submitted proposals to build such machines. After staff study, and upon the recommendation of its General Advisory Committee, the Commission approved, in April, the following specific plans for machine construction:

> A 30-foot-radius proton-synchrotron to be constructed at Brookhaven; to yield protons with energies between two and three billion electron volts (BEV); to take about three years to build; and to cost approximately $3,000,000.
>
> A 55-foot-radius proton-synchrotron to be constructed at Berkeley; to yield protons with energies between six and seven BEV; to take four or five years to build; and to cost approximately $9,000,000.

The Brookhaven machine, accelerating protons in a track almost four times the radius of that of the present Berkeley cyclotron; will develop energies about seven times as great—sufficient to produce mesons plentifully. The Berkeley proton-synchrotron is expected to accelerate particles with approximately 18 times as much energy as the 184-inch cyclotron. Not even its designers venture to predict the nuclear phenomena that it will reveal.

The ring-shaped magnet of the proposed Berkeley proton-synchrotron will require 10,000 tons of steel, approximately the quantity needed for a heavy cruiser. When it is considered that the proton, the nuclear particle to be controlled by this magnet, weighs only one in 17 million billion billion parts of an ounce, some conception of the forces applied to the particles may be obtained. In both machines, protons will be accelerated nearly to the speed of light — the maximum speed possible under the theory of relativity. In the Brookhaven proton-synchrotron, the particles while being accelerated will travel a distance of more than 150,000 miles — the equivalent of six times around the earth — in less than a second's time.

The synchrotron principle for the multibillion-volt acceleration of protons was conceived independently during the war by physicists in the United States, Great Britain, and Russia. Thus far the only known plans for such machines abroad have been made at the University of Birmingham, England, where construction is already under way.

Design of the American proton-synchrotrons is the achievement of two exceptionally competent teams of nuclear physicists. The Berkeley Radiation Laboratory has pioneered the entire development of high-energy nuclear bombardment. The Brookhaven Laboratory is a center of nuclear research for the great universities of the East. At these two locations the new machines will be ideally situated for maximum utilization of talent in the particle accelerator field.

Accelerators in the U. S.

Today there are more than 50 particle accelerators operating in the United States in the high-energy (million electron volt) range. An almost equal number are now scheduled for construction. A few of these, notably the synchrocyclotrons under construction at Columbia University, the University of Chicago, and the Carnegie Institute of Technology, are to be giant atom smashers with power in the range of that of the 184-inch cyclotron, designed to extend the frontiers of fundamental knowledge.

The great majority of them, however, are laboratory workhorses intended to operate, day in, day out, bombarding various target substances to get information and to produce materials obtainable in no other way. The information that they produce—about the nuclear characteristics of materials, for instance, or the behavior of nuclei under bombardment, or the fission and transmutation of elements — is basic to many kinds of scientific work and particularly to the development of atomic energy. The actual materials that they produce — isotopes not obtainable from atomic piles — are essential in today's laboratories and especially in the investiga-

tion of such problems as the effect of radiation and radioactive materials upon living things.

Accelerator Program

There are now seven particle accelerators of various types working in the Commission's program. Three more are under construction; and 10 others are planned.

Accelerators Now in Operation—Accelerators now in operation in the Commission's program are located at the Radiation Laboratory in Berkeley and the Los Alamos Scientific Laboratory. In addition to the 184-inch cyclotron, Berkeley has a 60-inch cyclotron (a pioneer machine, in which plutonium was first produced), which has operated steadily for more than a year bombarding materials for the Commission's research projects, chiefly in the field of biology and medicine, at Berkeley and Oak Ridge. Also at Berkeley is a linear accelerator constructed on an experimental basis to determine the possibility of producing billion-volt protons by straight-line acceleration. Now that experience has shown the proton synchrotron design to be more feasible for this purpose, the completed section of the linear accelerator has been put to work in physical investigations in the 20-40 million-electron-volt range. At Los Alamos are four accelerators working in the specialized physical research associated with the program of that laboratory: a 40-inch cyclotron, a 20-MEV betatron, a 2-MEV Van de Graaff generator, and a 200-KEV Cockcroft Walton accelerator.

Now Under Construction—Now under construction in Commission laboratories are:

A Synchrotron (virtually complete) at Berkeley which will for the first time accelerate electrons to energies of 300 million electron volts. The machine may prove capable of splitting nuclear particles: neutrons and protons.

A Van de Graaff electrostatic generator (4 MEV) at Argonne National Laboratory, chiefly for study of the nuclear characteristics of materials used in the reactor program.

A Van de Graaff generator (3.5 MEV) at Brookhaven National Laboratory, for general nuclear research.

To Be Constructed—Scheduled for construction, in addition to the two previously described multibillion-volt machines at Brookhaven and Berkeley, are:

Two 60-inch cyclotrons (30 MEV) for Argonne and Brookhaven National Laboratories, to be used in both physical and medical research.

Five betatrons for various laboratories of the Commission and institutions in its program, to produce high-energy radiations for use mainly in medical research.

A Van de Graaff generator (12-MEV) for Los Alamos Laboratory, for special research in nuclear physics. This type of electrostatic generator makes possible a variation and precise control of particle energy not feasible with the multimillion-volt cyclotrons and synchrotrons, and the Los Alamos machine will provide data much needed for solution of the nuclear physics, chemistry,

and engineering problems of that laboratory. It will be more than twice as powerful as any similar machine now in existence.

The Commission's joint support of a scientific program with the Office of Naval Research will include financial assistance for the operation of a number of other particle accelerators engaged in research associated with atomic energy in university laboratories throughout the country.

Atomic Power

There has been extensive discussion and speculation on the possibilities of atomic power and in some instances unwarranted optimism as to the character of the technical difficulties and the time required to surmount these difficulties. Following is a report to the Atomic Energy Commission by its General Advisory Committee[5] stating the Committee's evaluation of the prospects for useful power from nuclear energy.

➤ THIS PAPER proposes to discuss considerations that will determine the answers to the questions:

When shall we have heat and power from atomic energy?

On what scale will this be available?

How much will it cost?

Even if a full account of the events of the next decades were available to us, we would have to give a fairly complex answer to these questions. Thus, the first instances of the generation and uses of heat or power are likely to be on a small scale and be uneconomical. Further development may increase the scale without substantially improving the economy, and many steps surely lie between the present and the ultimate future in which atomic power is possible, economical, practical, and abundant.

At present, there already exist nuclear reactors which produce atomic power as a byproduct but not in a usable form. The large reactors at Hanford, made up of natural uranium and graphite and used in the production of plutonium for atomic bombs, generate great quantities of heat at low temperatures, and this heat is carried away in the water of the Columbia River. The much smaller uranium-graphite reactor at the Oak Ridge National Laboratory, used for research purposes and for the production of radioactive isotopes, generates heat which is dissipated in the air. A similar reactor is under construction at the Brookhaven National Laboratory. The uranium-graphite and the uranium-heavy-water reactors at the Argonne National Laboratory are used for research purposes and their small energy outputs are also wasted. The re-

[5] Members of the AEC General Advisory Committee are: Dr. J. Robert Oppenheimer, Director of the Institute for Advanced Study, Princeton, N.J., chairman; Dr. James B. Conant, President of Harvard University; Dr. Lee A. DuBridge, President of California Institute of Technology; Dr. Enrico Fermi, Professor of Physics at the Institute for Nuclear Studies, University of Chicago; Dr. I. I. Rabi, Chairman of the Department of Physics, Columbia University; Hartley Rowe, Vice President and Chief Engineer of the United Fruit Company; Dr. Glenn T. Seaborg, Professor of Chemistry at the University of California; Dr. Cyril S. Smith, Director of the Institute for the Study of Metals, University of Chicago; Hood Worthington, E. I. duPont de Nemours & Co., Inc.

actors at the Los Alamos Laboratory, made up of enriched uranium or plutonium and used for research in connection with atomic bombs, operate at a very low power and dissipate their heat into water or into the air. Thus, none of the reactors now in existence produce usable power. However, all of these reactors supply valuable information for the development of power reactors.

There are numerous scientific and technical problems that must be solved before atomic power can become a practical reality. Some of these are connected with generating energy at high temperatures, for no other sound method of applying atomic energy usefully as energy has as yet been proposed. This problem of high-temperature energy generation is essentially one of finding suitable materials for use in a nuclear reactor, suitable forms for the fuel, for structural elements, for coolants, and for moderators. But even in a program focused primarily on high-temperature energy, novel considerations limit the kinds of material which can be used. Thus, any reactor must include one of the two fissionable elements, uranium and plutonium. Materials of the reactor must be able to withstand not only high temperature, but the high levels of radiation which are necessarily present if the power is not to be altogether trivial.

To these obvious and necessary requirements, further desirable but optional criteria must be added. For example, it is undesirable to use in a reactor materials which absorb many neutrons, since the investment in nuclear fuel would thereby be increased and its conservation impaired. It is undesirable to use materials or reactor designs which give a very short life without recharging, since this not only works against economy because of the cost and inevitable losses in reprocessing reactor components and fuels, but also limits the adaptability of the source of power. It is undesirable to build reactors in which the power per unit of fuel invested is very low, since this will clearly involve rather large capital fuel costs. It is desirable that the reactor design have as little net consumption of fuel per unit of power as possible, or even that it have a net gain of fuel, a so-called breeding, as power is generated. All of these considerations bear on increasing the possible scale and decreasing the probable cost of atomic power.

However, it is likely that in many early reactor designs these criteria will not be adequately satisfied. These reactors will involve relatively large charges of fuel, relatively low power per unit of fuel invested, frequent recycling, and a high net consumption of fuel per kilowatt obtained. They will also probably operate at moderate temperatures where the thermodynamic efficiency is low and where certain specialized applications may not be possible.

Two reactors are now authorized for construction which should produce atomic power and which should be completed within the next two or three years. Neither unit can conceivably rate as an economic producer of power. But, as a result of experience gained in these, and their successors, there will start a program of reaching higher temperatures and at the same time satisfying some of the

criteria necessary for practicality and economy. Fairly practical reactors, that might be useful for special purposes, may then be available on an experimental basis within a decade.

The widespread use of atomic power will also depend on the availability of nuclear fuels. There are three possible nuclear fuels—Uranium 235, Uranium 233, and Plutonium 239. Uranium 235 occurs to the extent of only 0.7 per cent in natural uranium and can be used either in that highly dilute form, or after preliminary enrichment in isotope-separation plants. It is the natural source of all nuclear fuels. Plutonium and Uranium 233 are artificial nuclear fuels obtained in the first instance by absorbing some of the extra neutrons from the fission of Uranium 235 in either Uranium 238 (the inert part of natural uranium) or in thorium. These elements, once formed, can be separated by chemical means from their parents, a simpler process than the physical separation of isotopes but fraught with great difficulties because of the enormously high radiation levels.

The selection between the various types of fuel will be, in the long run, a matter of economics and availability. If uranium ores should be found to be very plentiful even if low grade, it would probably be cheapest and best to use natural or, if needed, slightly enriched uranium as a fuel directly. The fuel might then be discarded without chemical treatment after, say, one per cent had been utilized, which would give about 100,000 kilowatt-hours of heat per pound of the original material.

In anticipation of a rapidly growing shortage of uranium, great attention has been given to "breeding," a process in which plutonium or Uranium 233 is produced by the power reactor at a rate greater than its consumption. It is theoretically possible—but in practice will be very difficult—to build an industrial reactor that will cause excess neutrons to be absorbed in a blanket of either U 238 or thorium, producing plutonium or U 233 which can serve as new fuel to continue the operation indefinitely as long as new natural uranium or thorium is supplied. This greatly increases the availability of fuel, for most of the uranium, not just the small 235 fraction of it, is consumable, and moreover the larger resources of thorium also can be used. It might even be possible by these means to build up fissionable material faster than it is consumed.

Nevertheless, the engineering difficulties associated with breeding are enormous. The conditions which have to be fulfilled to obtain high neutron economy are difficult to reconcile with those needed to obtain a high power output for a given material investment. There are acute chemical engineering problems associated with the repeated treatment of partly depleted fuel and the extraction of new fissionable material from the uranium or thorium blanket. Such procedures are complicated by the enormous radioactivity and have to be repeated many times before the fuel is completely consumed. The process must give virtually complete recovery at each stage if the physical reproduction is to be reflected in active material stocks.

Another very important factor in

the possibility of widespread use of atomic power will be the cost of uranium. At the price of uranium compounds before the war, the cost of uranium fuel would compete with coal under almost any condition. However, the available supply came from fairly rich ores and was fairly limited. It may be assumed that the supply could be increased through intensive geological research and prospecting. Large use of uranium, however, will certainly drive the mining industry to the exploitation of poorer and poorer deposits. The cost will be determined by the cost of handling large amounts of rock, although it may conceivably be reduced by the sale of useful byproduct minerals.

If unfavorable assumptions are made about the cost of uranium and the technical practicability of breeding, the result is that atomic power would not compete with coal power in the United States except in regions where the cost of transportation of the fuel from the mines is the determining factor, or under other special conditions where the small bulk and weight of the uranium fuel are particularly valuable. On the other hand, if favorable assumptions are made about the cost of uranium and the technical practicability of breeding, the ultimate capacity may become comparable to even larger than the present coal industry and will operate at a lower cost, at least as far as fuel expenditure is concerned. At the present time, sufficient knowledge does not exist to make a definite choice between these two alternative possibilities. It should be pointed out that, in either case, the cost of a nuclear-fuel power plant will be substantially greater than that of a coal-burning plant of similar capacity.

Even on the assumption of a most favorable and rapid technical development along these lines, a word of caution is needed as to the time scale. We do not see how it would be possible under the most favorable circumstances to have any considerable portion of the present power supply of the world replaced by nuclear fuel before the expiration of 20 years.

Screening for Cancer Cure

➤ SEARCH for a chemical cure for cancer is being aided by a mass screening technic similar to that used in the wartime search for anti-malaria chemicals to replace quinine.

The screening is being done in Washington by the CBCC. CBCC is the short name for Chemical-Biological Coordination Center. The CBCC is operated by the National Research Council with funds from the Army, Navy, National Cancer Institute and American Cancer Society.

Hundreds of thousands of chemical compounds, made by industrial, government and university laboratories, will be catalogued by mechanical minds and fingers in the CBCC machines for their biological activity.

Of some 4,000 already catalogued, 800 have been sent to collaborating university and government laboratories for testing as possible remedies against cancer and other diseases.

Radioactive Tracers Measure Minute Quantities of Matter

First Tracer Chemistry

A Classic of Chemistry

A new technique was pioneered in this paper by the Danish chemist who, less than ten years later, was one of the discoverers of the element Hafnium. Tracer methods become more important year by year.

RADIO-ELEMENTS AS INDICATORS IN CHEMISTRY AND PHYSICS. *By G. Hevesy, Ph.D. In Chemical News, London, Vol. 108, Oct. 3, 1913.*

➤ BY MEANS of an *a*-ray electroscope of ordinary sensitiveness it is possible to measure accurately as small a quantity as 10^{-17} grms. of a radio-active substance having a half-value period of one hour. The extraordinary simplicity and at the same time sensitiveness with which it is possible to measure these extremely small quantities of radio-active bodies makes them of the greatest use not only in studying substances in great dilution but also as indicators of physical and chemical processes.

Radio-active indicators may be conveniently divided into two principal groups. To the first group belong those whose use as indicators depends only on their physical properties and not on their chemical properties. Some examples of the use of radio-active indicators of this kind are the following:—

It is only necessary to know that the radio-elements composing the active deposits are metals in order to test the formula of Arrhenius connecting the variation of velocity of solution of metals in acids with the temperature. This has been lately carried out by Miss Ramstedt.

It is known from the kinetic theory that the concentration of a solution varies with time, and this problem, which could not be attacked by ordinary methods, has been made experimentally feasible by the use of radio-active bodies as indicators. (Svedberg, Smoluchowski).

The existence of colloidal solutions of radio-elements has been lately established by Paneth and Godlewski, and experiments have been undertaken on the formation and precipitation of these colloids using radio-active indicators.

The emanations, the only gaseous radio-elements, have been employed to establish the validity of the gas laws, especially that of Henry's law for extremely small partial pressures. (Bruhat, Boyle).

Fick's Diffusion Law has also been shown to hold accurately for bodies in infinitely small concentration by making use of radio-active substances.

It is often a question of practical interest to the chemist to know how often it is necessary to wash out a pipette or a beaker in order to remove the last trace of the solution it had contained. This problem can be investigated with extreme ease when radio-active indicators are used.

The fact, however, that most radio-elements are throughout in all chemical properties exactly similar to some of the common elements (for instance, radium D and thorium B are non-separable from lead, thorium C and radium E from bismuth, etc.) allows these bodies to be used chemically as indicators of the bodies from which they are known to be non-separable. Radium E can be used as an indicator for bismuth, radium D for lead, etc.

If 1 mgrm. of lead is mixed with a quantity of radium D which gives 10,000 units of activity in an electroscope, one-millionth part of this mixture is easily detectable by the radioactivity of radium D. In this way 10^{-6} mgrms. lead is quantitatively determinable.

By this method also the solubility of the difficultly soluble salts of lead, such as the chromate and the sulphide, has been determined. Further, the amount of lead chloride entrained by a precipitate of silver chloride after washing the latter thoroughly with water is measurable.

Experiments on the electrochemical behavior of small quantities of lead and bismuth have been begun. By means of these indicators a study may be made of the electrochemical behavior of these metals for electrode potentials lying below the decomposition voltage, a problem which could not be investigated by any other means.

Of especial use are the indicators for investigating the diffusion and mobility of ions in extremely small concentration. Data are already available on the diffusion rate of lead salts down to a normality of 10^{-14}.

Water Softened by Polyphosphate

▶ HARD WATER is softened by dissolving glassy sodium phosphate in it. This keeps the calcium and magnesium in the water from combining with soap, the American Chemical Society was told by Dr. Everett P. Partridge, Hall Laboratories, Pittsburgh.

This chemical is one of the group of polyphosphates which are produced in large quantities and widely used in many industrial processes, including tanning sole leather and dyeing textiles.

Polyphosphates are used also in controlling the properties of mud used in drilling oil wells, improving the coating of paper for use in picture magazines, and conditioning water so that it will not form scale in boilers. The paste of titanium oxide and water used in paints will flow like milk if a small amount of sodium phosphate is added.

Chemists are unable to explain the action of the glassy sodium phosphate in softening water, he stated. Some ordinary water softeners work by converting the soluble calcium and magnesium salts in the water into insoluble particles which settle on the bottom of the container. With the glassy sodium phosphate the water remains clear and there are no settlings. This softening without precipitation chemists call sequestration.

Semi-Conducting Metal Replaces Vacuum Tube For Radio Circuits

Germanium Transistor for Radio

➤ THE GLASS vacuum tube in your radio has its first rival in 40 years—a bit of semi-conducting germanium metal that amplifies or oscillates current without the complexity of plates and wires in an airless bulb.

This new transistor, as it has been christened, should allow more stable and durable radios, television sets and electronic devices. Radios may be made smaller, when the new cylinder, slimmer than a pencil and less than an inch long, comes out of the development laboratories into production.

Because the new device has no filament that must heat up before it operates, it goes into action instantly. It will do some electronic tricks that conventional vacuum tubes can't do. This means new electronic devices.

Invented at Bell Telephone Laboratories, the transistor's operation is possible because the ability of a semiconductor to carry electrical current can be controlled. This is done by changing the electronic structure of a small bit of material under the influence of the incoming current, fed to it through a fine "cat's whisker" wire. The current coming out of the other wire, just about two thousandths of an inch away, is boosted in volume a hundred fold.

Dr. John Bardeen and Dr. Walter H. Brattain made the key investigations in the Bell Telephone Laboratories that produced the transistor, while the program was initiated and directed by Dr. William Shockley.

Since electrical speech waves traveling between telephones can be amplified, the transistor will probably replace the vacuum repeater tubes now used on long distance and other telephone lines.

A superheterodyne radio set with about a dozen transistors instead of conventional tubes has been demonstrated and probably is the forerunner of a new family of radios.

Because it can oscillate as well as amplify, the transistor will be used to produce standard frequency tones and for other similar uses.

Germanium metal specially treated is the semi-conducting material used, but other semi-conductors include silicon, some metallic oxides and other compounds. Semi-conductors have electrical properties intermediate between those of the metals and insulators.

Semi-conductors, copper oxide and selenium have been used previously to rectify alternating to direct current, and silicon has been used as a detector, particularly for microwave radio apparatus.

The transistor as now developed has a frequency limitation of about 10,000,000 cycles per second, but it is quite satisfactory in the television ranges.

Poison ivy is America's number one nuisance plant.

Scientific Co-operation Urged by British Nobelist

The Scientist in Industry

by Sir Edward Appleton

Secretary of the British Department of Scientific and Industrial Research, winner of the 1947 Nobel Prize in Physics, speaking at a meeting of the Federation of British Industries.

➤ Nearly a hundred years ago, Clerk Maxwell, one of the greatest physicists of all time, began a lecture with these words, "An atom is a thing which cannot be cut in two." I don't suppose that anyone quarrelled particularly with this weighty pronouncement at the time. For such a conception of the atom was entirely consistent with the scientific knowledge of the day. But during the latter half of the same century this model of the atom proved entirely inadequate. First J. J. Thomson showed that the atom has a structure and that electrons could be chipped off its exterior. Then Rutherford showed how the very citadel of the atom, the nucleus itself, could be stormed; while, only nine years ago, Hahn, the German scientist, showed that, in the case of the uranium atom at least, the process of nuclear fission was nothing other than the complete cleavage of the atom. In other words, one of the characteristics of the uranium atom is precisely this—that it can be cut in two! Now—and this is the point I wish to emphasize—only six and a half years elapsed between Hahn's discovery and its application in that most frightening product of applied research — the atomic bomb; and this was in spite of the fact that during the first half of that period there was little intensive development.

The case of the atomic bomb is, of course, exceptional, but it does illustrate most strikingly the rapidly increasing momentum of scientific and technological progress, and of the way in which the gap between scientific discovery and practical use can be, is being, and will be, more rapidly bridged. It also illustrates how a vast army of workers didn't wait for discoveries and inventions merely to happen; but consciously and deliberately applied their minds to *make* practical discoveries and *hit on* new inventions. It is, at once, a lesson on what applied science can do when it really tries!

It is, of course, unlikely that in the post-war field of civil science, with its broader front, there can now be anything like the same concentration of effort that produced the atomic bomb. For during the war this concentration, and others like it — for example on radar — was achieved by neglecting fundamental research, particularly in our Universities. Nowadays the pattern of our scientific effort has had its balance restored, and it is about some aspects of that balance that I want to speak this afternoon.

It always seems to me convenient to think of the pattern of scientific research effort in this country as being shaped like a triangle, with University science at one corner, Government science at another and Industrial science at the third. The advantage of

this method of portrayal is that it is seen that each corner is linked to the other two by way of the connecting sides. For it is absolutely vital that there should be no segregation—no isolation—of research effort. Each corner of research is vitally dependent for stimulus and assistance on the other two.

Now we look mainly to our University corner for fundamental scientific research. In this case the worker seeks a deeper insight into natural phenomena. Under such conditions a man is free to explore whatever byways may appear attractive and fruitful. Here the only discipline is that of science itself.

In the other two corners, of Government science and Industrial science, the bias is definitely on the side of applications, so that the scientific worker is subject to the further discipline of having to follow specified objectives, wide though these may be. He employs the same methods and approaches his problems in the same way as his University colleagues, but the fields he can enter and explore must of necessity be restricted by the interests of the organization he serves. I would say, however, without any hesitation, that in both Government and Industrial laboratories, the more liberally these restrictions are interpreted, the better will be the scientific health of the men who work in them.

It was the first World War which made the people of this country realize the value of science in industry. Previously, it had scarcely been considered worth while to dabble in the risks and uncertainties of industrial research. It seemed preferable for us to leave this to someone else and compensate him if the results turned out favourably. The first World War provided a rude awakening to the consequences of an industrial policy of this kind. During that period we had to set about making for ourselves the fine chemicals, dyestuffs, optical glass, scientific instruments and many other materials and supplies for which we had previously been relying on friends and foes alike. The lessons we learned from the disastrous policy of relying on other people are well stated in a famous paragraph from the report of the Ormsby-Gore Committee on Research Co-ordination, which sat after the War:—

"No nation can advantageously depend only upon the efforts of other nations for the purposive promotion of knowledge. This is not only because such dependence is an ignoble parasitism, but because, in the field of international relations no less than in national life, the power that comes from knowledge comes from its early and rapid use, and from close association with the men who have actually gained it. It is now apparent that long before the new century opened this country was losing heavily by leaving the advancement of knowledge and of its uses too much to the accidents of individual effort and to the caprice of individual munificence."

Two results followed from our experience during the first World War. First a number of firms turned to science for help in their difficulties and began gradually to build up their own research departments. Second, Government decided it was essential to give increased support to fundamental research, to encourage industrial research and also itself to embark on research on subjects of general

community interest. The concrete realization of Government policy was the formation of the Department of Scientific and Industrial Research. This is not the time to say much about D.S.I.R's own achievements or about the way in which we have tackled our job. Broadly, we have tried in every way to assist industry in bringing science to bear on its problems, and above all we have encouraged that close and habitual association between industry and science, which is essential if advantage is to be taken of the opportunities of applying major scientific discoveries when they arise. In all our actions we have recognized that while it is impossible to plan discovery it is quite possible to plan *for* it.

There is no doubt that, with the ever increasing complexity of both science and industry, the proper use of scientists in industry has become a managerial problem of the first magnitude. This has been recognized by the Federation of British Industries in the formation of your Industrial Research Committee.This Committee is warmly to be congratulated on the series of stimulating Conferences it has held in different parts of the country, and on the valuable surveys it has produced on the present position of research in industry. We, in D. S. I. R., have greatly valued the close collaboration which has grown up between your Committee and our own staff.

Now one of the main reasons which makes the proper use of science in industry a managerial problem lies in the rapid rate of scientific progress to which I have already referred. Scientific knowledge is growing with amazing speed and the opportunities for applying it are so enormous and so varied that it is essential to be selective. No firm, not even the largest, could hope to carry through successfully to the production stage all the ideas which seem to be feasible and attractive. Selection involves many problems, the solution of which depends on other factors besides purely scientific ones. There is the question of development costs. Then there are production difficulties to be overcome; the question of fresh capital expenditure and whether the probable market for a new product will be sufficient to cover development and other costs in a reasonable time. Apart from such financial considerations there are, at present, the questions of whether the necessary manpower for development is available and whether new equipment, which may be necessary, can be obtained. All these problems affect individual firms differently according to their size, according to the type of industry to which they belong and the special skill they command. It is, therefore, impossible to generalize except to say that, in any firm, the various branches concerned will approach these problems differently. A research department, for example, may regard the possibility of solving them far more optimistically than a more cautiously-minded engineering department. A research department may even be more optimistic than the most exuberant sales department. The only solution is for management itself to hear the evidence and to make up its own mind on the facts presented. That was the way in which similar problems were solved in this country in the war. The decision, as you know, whether a new weapon was to be developed was

made by the General Staffs, acting alone or together, after having been put in possession of the full information from the scientists on the technical possibilities of a new idea, and from other authorities on the production difficulties involved and their possible effect on other supplies. Finally the General Staff took into account, before coming to a decision, the training effort required to get the new weapon successfully introduced into the Services. It is true that financial considerations then seldom arose and for this, and other reasons, conditions are obviously different in war and peace. Nevertheless, it is undoubtedly true, that our success in the war depended largely on the mutual understanding which grew up between the General Staff, the scientists, and the production men. In peace we need this same sense of partnership developed between management, science and the other branches of industry including, of course, labour.

I hope I may be forgiven by representatives of management present this afternoon if I disgress at this point to tell them something about the human characteristics of their scientific staff. Now scientists are curious creatures in many ways but, like most other folk, they have their ambitions and they respond to stimulus and incentive. I don't think it can be said that their ambitions are particularly worldly. Indeed I think it can be claimed that the thing they desire most is the esteem of their fellows in the scientific world. For stimulus they require contact with their scientific brethren—scientific talk—"shop" if you like—the try-out of one man's ideas on another—criticism—and so on. I don't think a desert island is the best place for scientific research. As for incentive, we must always remember the enthusiasm and the challenge of the scientific chase. My experience is that science, whether the objective be a greater insight into some natural phenomenon, or some more practical task, can be an adventure as well as a job.

But I feel I must add one further word on these human aspects of the scientist's work. Science is often said to be a disinterested search for knowledge, but I think that requires a little further qualification. Being human, one just cannot help hoping that an experiment will yield results which fit in with one's own ideas and theories. What is then essential is that the discipline of science should steel one to complete impartiality in interpretation.

But, just as we ask from management a sympathetic understanding of the scientist's approach to his own work, so we must ask the scientist to make his own contribution to the simplification of managerial decision. I've more than once said that, as I see it, the mission of the scientist is not only to add to natural knowledge but also to interpret his results to his fellow men. For the second purpose the scientist has to be articulate in the right way. Taking the special case of the scientist in industry, he must be able to expound the results of his work to management without clouding them in a framework of abstruse scientific phraseology. I grant you that it is by way of a framework of scientific phraseology and imagery that his work has taken shape in his own thoughts, but it is the final result and its practical significance that

are of real concern to management as a basis for executive action.

Let me remind you that this very point of verbal communication of scientific results was once raised by Michael Faraday himself, at a time when he worked in this great Royal Institution. Writing to his mathematical friend Clerk Maxwell, he said:—

"There is one thing I would be glad to ask you. When a mathematician engaged in investigating physical actions and results has arrived at his conclusions, may they not be expressed in common language as fully, clearly, and definitely as in mathematical formulae? If so, would it not be a great boon to such as I to express them so? translating them out of their hieroglyphics, that we also might work upon them by experiment. I think it must be so, because I have always found that you could convey to me a perfectly clear idea of your conclusions, which, though they may give me no full understanding of the steps of your process, give me the results neither above nor below the truth, and so clear in character that I can think and work for them. If this be possible, would it not be a good thing if mathematicians, working on these subjects, were to give us the results in this popular, useful working state, as well as in that which is their own and proper to them?" If Faraday did not hesitate to ask for such a simplification I do not think others need do so.

Now the standpoint of the modern scientist's approach to an industrial problem is usually that there is probably a better way of doing most things. Don't forget that the scientist is familiar with novelty. He is brought up to interfere continually with Nature. The question to be settled is whether the new method is worth while industrially. In the past, it is the *way* in which such questions have often been settled that has led to feelings of dissatisfaction and frustration among scientists working in industry, —not so much because the answers have sometimes been given against them—for most scientists are usually quite reasonable people—but because they have felt that the answers have not always been based on ascertained facts so much as upon prejudice and hunches. Towards the end of the war the questions I have in mind were those which were settled by what was called Operational Research.

Now studies of this kind are by no means new in industry, but I fancy that in industry such investigations have hitherto been carried out by technologists, and it has been unusual for scientists to leave their laboratories to take part in them. Be that as it may, and by all means let us admit that operational research may well be a new name for an old subject; nevertheless there is no doubt that the discussions which have recently taken place on the use of operational research methods in industry have shown that there is a very wide field for their expansion. Operational research in industry—I wish someone would invent a better title for it—I take as meaning the application of scientific methods to estimate quantitatively the effect of changes in all kinds of factors which may influence industrial efficiency—so as to provide reliable data on which executive decisions can be taken. In other words it is the arithmetic of what happens when we make a change—and when

we don't. These methods can be applied to the study of a whole industry or to the operations of a particular firm. A number of these studies, so far made, have been carried out by the Research Associations who for many reasons are admirably fitted for the task. They have brought out very clearly some remarkable differences in productivity of apparently similar firms engaged in the same branch of industry, and what is more important have shown the causes of these differences.

In our own D.S.I.R. Stations we have used operational research methods on such problems as the study of the traffic carried by different roads and how the distribution of different types of traffic over the road affects the wear of the surface. We are employing similar methods in the study of the problems of road safety. In building research we have used operational research methods in studying bricklaying. But our most important single investigation in this field is into the problem of finding the most economical method of warming a house. And by *warming* a house, I really mean warming the *whole* house and not only a small semi-circle in front of one fireplace, while the rest of the house is arctic! In this work we are using a number of experimental houses. The experiment is in two parts. In the first, eight houses have been built identical in internal design, but with different degrees of thermal insulation. The heating systems inside are of two types only so that the scientist can find out how much fuel is saved by the better insulation under actual living conditions. In the second part of the experiment, 20 houses, with identical thermal insulation have been built; but in these houses the heating systems and the appliances are different and the results will show which stoves, grates, etc.—92 are being tested—are the best and most economical in fuel. At first the houses are empty and conditions such as temperature, time of stoking, and ventilation are controlled. When comparable data on the effects of the different variables have been obtained in this way the houses are occupied by tenants and the experiments continued. The aim, you see, is to get a precise picture of the conditions in the houses as they are when actually lived in. The experiment is obviously very complex but the stake is very great, because 60 million tons of coal are used, in varying ways, every year for domestic heating. This is operational research in its most highly developed form as applied to housing.

I believe operational research methods can be of particular value at the present time because they provide one method by which science can contribute effectively to the pressing problems of national productivity. A great deal of work which is now in the laboratory stage can have little real effect on production for at least two years and probably longer. The results of operational research can often, however, be applied without any such delay.

Finally it follows from what I have said that the scientist in industry must have three functions. First he must provide a scientific service for his industry or firm; secondly he must carry out research aimed at the devising of new and better processes, goods and materials; and thirdly, he

should also be a contributor to the world's scientific knowledge. As I have said, what scientists value most of all is the good opinion of their scientific colleagues and it is impossible for them to feel that they can acquire and retain this, if their work is so circumscribed and limited in outlook as to cut them off entirely from the main stream of scientific progress.

On this note I conclude. What matters most in any scientific activity, in industry or elsewhere, is not so much money and equipment, but men and leadership—above all leadership which understands men — and can make all the members of a research team feel essential; leadership which ensures that the joys of success and the disappointments, which are bound to come some time or other, are shared by all. In the past we, in Britain, have always produced such leaders—men with ideas and inspiration. From what I know of the younger scientific generation, I rather think we shall go on being able to do so.

Cobalt Metal by Electrolysis

➤ COBALT METAL can be obtained from the low-grade ores available in America by an electrolytic process which, as determined by a pilot plant of the U. S. Bureau of Mines, can be used commercially to get a good-quality cobalt at a cost far below current market quotations, Dr. James Boyd, director of the bureau, recently declared.

The investigation of cobalt production was carried out at Boulder City, Nev., and the ores were obtained from Idaho. Production methods include reducing the ore by roasting, and acid leaching to purify the product. The final purification process is electrolytic. A complete report on the technique is available from the Bureau of Mines.

Cobalt is one of the so-called strategic metals. It is used in magnets and high-speed steels, and in the new high-temperature alloys required for jet-propulsion gas turbines. Present supplies are obtained principally from the Belgian Congo, Africa, which is the world's chief source of this metal.

New Research on Salt Solutions

➤ A NEW STUDY of metals in contact with common salt solutions is being undertaken by Dr. Donald MacGillavry, Jr., associate professor of chemistry at Clark University, under a contract with the Navy.

The new research will involve the measurement of electric potentials, requiring the development of new precision measuring techniques, it was stated. The project was proposed to the Navy by Dr. MacGillavry, who has done previous work in the field.

One source of lecithin is soybean oil; commercially lecithin is used in textile dyes, confections, paints, leather tanning, medicine, ice cream, margarine and in bakery products as a shortening extender.

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